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CHARLES W. PRICE
PRESIDENT AND TREASURER
STEPHEN H. GODDARD
SECRETARY
CHARLES T. CHILD
TECHNICAL EDITOR
RUSSELL HOWLAND
GENERAL REPRESENTATIVE

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Time was when every telephone bore a conspicuous notice warning patrons against using it during a thunder-storm. The warning was a reasonable and very necessary one in the early days of the art, but to-day it no longer exists because the reason for it has passed away. Methods of protecting electrical circuits against damage by lightning have become so perfect that fear is no longer felt of any accident or danger from this cause. The telephone works practically as well during a thunder-storm as at any other time, and people no longer avoid the neighborhood of electric lights when they hear thunder. Indeed, people in cities are no longer timorous about thunder-storms, because the percentage of damage actually done by lightning is growing smaller every year in the larger towns.

THE OUTLOOK FOR BUSINESS.

With each succeeding year the differentiation of the twelve months into seasons of activity in electrical circles is becoming less marked. The summer of 1900 was probably the busiest that has ever been known in the electrical trades and industries in the United States, and that of 1901, now more than half gone, holds out every indication of eclipsing the record of the year before. At the same time, and notwithstanding the extraordinary activity which is going on in practically every department of electrical application, the outlook for next fall and winter is remarkably bright and indicates, perhaps, even an increased degree of activity in those seasons.

At the present writing the only factors which have appeared to be able to exert a detrimental influence to general industry are the strike in the steel industry and the unparalleled weather conditions which have threatened great damage to certain crops in the central states. Both these, however, appear to have been magnified and to be less disastrous than was anticipated. The steel strike is generally regarded as abortive and unlikely to succeed. The weather conditions in the West have greatly improved and fear of a destruction of corn and other food stuffs in that section has departed. Reports for the fiscal year recently ended have shown that the export trade of the United States has grown to the unparalleled total of a bilion and a half of dollars in the last twelve months.

To the careful observer of all these conditions and of the various aspects of the electrical industry it appears that another one of the great steps which have marked the advance of this department of human activity is about to be taken. With the electric light, the telephone, the telegraph and the trolley car, there was in each case a period of almost feverish activity in the building of new plants and the equipment of various places with these electrical utilities. In each case, after the country was supplied, the business took a more stable character, its growth depending upon the growth of cities and the steady increase in appreciation by the public of the value of the various electrical adaptations named. For several years there has been no great "boom" in electrical business, but the signs point to one as impending. Equipment of main-line steam railways must begin very shortly, and when it commences it will mark the largest advance that has been made in the history of electricity. Even to-day, when the astonishing development of trolley lines has gone to such an extent, the capital invested in main-line steam railroads is many times as great as that employed by surface electric traction. Into this great field the electrician must soon go. Even were not this outlook before us the great expansion of all varieties of industrial endeavor, the up-building of a mighty commerce with foreign nations, and the ever-growing wealth of the United States demanding constantly new apparatus for convenience, comfort and luxury, give the electrical business an outlook such as it has never had before in its history. It is believed that the coming winter will be the most active that has been known in the experience of electrical people.

WATER POWER AND PUBLIC WEALTH.

On other pages of this issue will be found a description of the present condition of the great water-power and electrical installation at Massena, N. Y.

"Whoever could make two blades of grass to grow where only one grew before would deserve better of mankind than a whole race of politicians," said Dean Swift. Precisely in the same measure, whoever seizes upon a natural force and converts it to the immediate use of mankind deserves better than almost any other kind of benefactor. This is because the development of a power is one of the most direct ways of setting to work wealth-

producing agencies that can be imagined, and the construction of a power plant not only produces wealth but produces a source from which continual supplies of wealth flow out to enrich succeeding generations. How important these natural sources of wealth are may be judged from an inspection of the history of the water powers and their influence upon the development of various activities.

When the country now comprising the United States was first settled no part of it was more barren or uninviting than the region of New England. Swift rivers made their way to the sea over barren and unfertile tracts of country which suffered from a repellant climate and an absence of most of the characteristics which go to make up natural wealth. Yet in a surprisingly short period of time this section of the country, in competition with others apparently much more favored by nature, became the wealthiest part of the Union by reason of the manufacturing industries which grew up around the various water powers found on its streams. The cotton manufacturing industry was diverted more than a thousand miles from the cotton producing region by the existence of these streams of water. In later years we have seen a manufacturing city of no mean proportions grow up around the cataract of Niagara, while here and there, along both the Atlantic and Pacific slopes of the country, are to be seen thriving and energetic towns rapidly growing and increasing as centres of production, and simply because water power exists at their sites.

The great chain of fresh-water lakes and streams that extends from Minnesota to the maritime provinces of Canada, and for much of its length forms the international boundary, abounds in magnificent water powers. At Sault Ste. Marie and at Niagara these have been already exploited in some degree. Further down the St. Lawrence River, at Montreal, advantage has been taken of the Lachine Rapids to erect a fine water-power plant and make available a constant source of energy. At Massena advantage has been taken of natural conditions of a most extraordinary variety to produce a very great power development, at what it seems reasonable to believe will be a comparatively small cost. While it is dangerous to prophesy much it seems fair to look ahead at the future and see the effect of this power exploitation upon the industrial conditions of northern New York. The town of Massena, which is now almost an ideal farming centre—a village supported by and existing for an agricultural population in its vicinity—must necessarily become a manufacturing centre of great importance. It has every natural advantage, and even a short time will likely work a remarkable change in the appearance and surroundings of the place.

The real philanthropists, after all, are the men who spend their money, their time and their energy in the erection of great engineering works such as this at Massena. Doubtless the profit they enjoy is large, as it should be. No one can reasonably grudge to such an enterprise the profit which it deserves, but great as this profit may be it is incomparably smaller than that which will accrue to the whole region that the power development serves—a continuous and ever increasing inflow of wealth and prosperity.

THE DECADENCE OF ISOLATED PLANTS.

When electric lighting from central stations was first undertaken the radius through which it could be successfully and cheaply accomplished was very limited. The consequence was that many large users of electric light and power put in their own installations, which, in many instances, exhibited an apparent economy. Indeed, it was often a case of an isolated plant or nothing.

With the gradually increasing radius of economical supply there has come to be less and less reason for the maintenance of isolated plants, especially as a wider acquaintance with them has shown their proprietors that the apparent saving due to their use has been only apparent. It is as true of the electric light business as it is of any other manufacturing industry that production on a large scale greatly cheapens the output and often improves it as well. For this reason, to-day, in most metropolitan centres, at least, electric light can be furnished even to very large consumers at less rates than they themselves can make it for. It is gratifying to notice that the public has waked up to this fact and that the isolated plant, once so common, is rapidly becoming a sort of curiosity. Indeed, to-day it has little excuse for existence, and in most cases its survival is due to a lack of understanding of the fundamental troubles with it, or a disinclination on the part of its proprietor to change established methods. It is very difficult for a small plant lacking expert supervision to compete with a great central station using large and efficient machinery, operated under the best possible conditions of service and transmitting its product with insignificant loss to the consumer.

In most isolated plants, however, very little attention is paid to keeping an exact record of the cost of electric light produced. The time-honored argument that it is necessary to have an engineer about the place anyhow, because he must attend to the steam-heat boilers, etc., is meaningless. There is a tendency for the isolated plant accounts to mix themselves with the general maintenance and operative expenses of the building in which the plant is located, and it is very rare that the proprietor of such an establishment accurately knows what electric light made by the isolated system is costing him. It is safe to say that in nine cases out of ten if he did know he would get into correspondence with the central station immediately.

The long extract from the patent specification covering the new form of storage battery due to Mr. Thomas A. Edison, which appears on another page of this issue, is an exceedingly interesting account of difficult and ingenious labors carried to a practical conclusion. Perhaps this specification gives a better idea of the difficulty encountered in the design of this battery than any statement that has yet been made concerning it.

The cell seems to be entirely different from others that have preceded it and the result of its practical application is awaited with deepest interest by every one who has to do with accumulators in any form. The promise held out by the somewhat short and incomplete description contained in Dr. Kennelly's original paper describing this type of cell—that the new battery would possess extraordinary advantages over other forms—seems to be well borne out by the patent specification referred to. It is to be hoped that we shall soon have full data of service tests of these cells under the conditions ordinarily met in practice, especially in connection with automobile service.

THE THEORY OF ALTERNATING DYNAMO ELECTRIC MECHANISMS—XXXVI.

BY W. ELWELL GOLDSBOROUGH.

In Fig. 102 this fact is demonstrated. Here $O'A^I$ and $O'A^{III}$ represent the electro-motive forces developed respectively by E^I and E^{III}. The vectors OA^I, OA^{III} and OO' are the electro-motive forces apparent

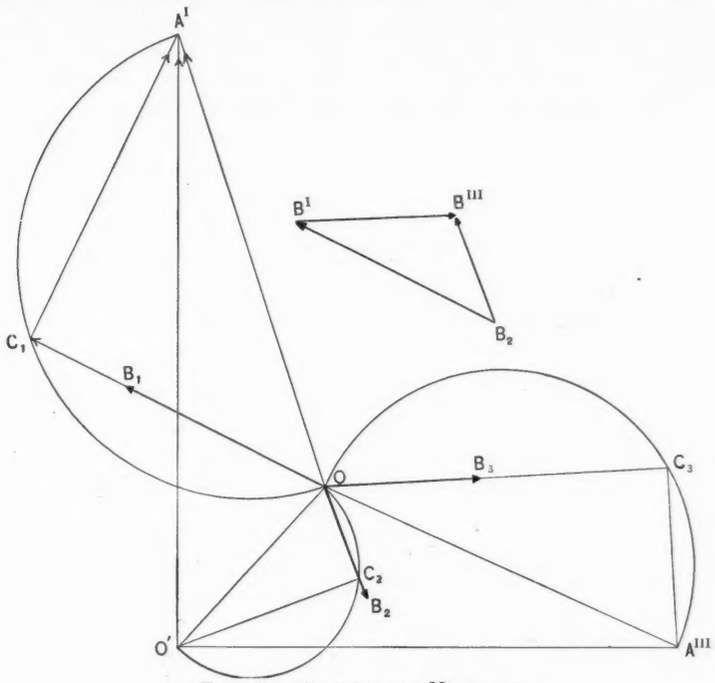


FIG. 102.—ALTERNATING MECHANISMS.

at the terminals of each of the circuits of Fig. 98. The vector OB_1 is the current flowing in the circuit A_1O, and is equal and parallel to the vector $B_1^{III}B_1^I$ of Fig. 101. The vector OB_3 is the current flowing in the circuit A_3O, and is equal and parallel to the vector $B_3^IB_3^{III}$ of Fig. 101, and finally the vector OB_2 is equal to the current flowing in the circuit OA_2. It is equal and parallel to the vector $O'B_2$ of Fig. 101, but is given a phase position differing by 180 degrees from the vector $O'B_2$ of Fig. 101, in order that the three-line electro-motive forces may be represented as uniformly pointing away from the junction point O of Fig. 102.

Upon each of the three-circuit electro-motive forces the electro-motive-force triangles corresponding to the circuits have been constructed. The sides of these triangles can be shown, by reference to Fig. 101, to be equal to the resultants of the electro-motive-force vectors corresponding to the sides of the electro-motive-force triangles of the circuits which are shown in Fig. 101. For instance, the resistance electro-motive-force vector OC_1 of Fig. 102 is equal to the vector difference of the resistance vectors $A_1^IC_1^I$ and $O'C_1^{III}$ of Fig. 101, and the reactance vector C_1A^I of Fig. 102 is equal to the vector difference of the vectors $C_I^IA^I$ and $C_1^{III}A_3^{III}$ of Fig. 101.

Finally, the maximum difference of potential which exists between any two points in the system shown in Fig. 98 occurs between the terminals A_1 and A_3. From Fig. 102 this potential difference can be obtained, as it is equal to the vector distance between the points A^I and A^{III}.

There is one other fact which should not be lost sight of in this discussion. It is that the current flowing in the circuit OA_2 is the resultant of currents flowing in the circuits OA_1 and OA_3. This is shown in Fig. 102, since the vector B_2B^{III} is equal and opposite to the vector OB_2, the vector B^IB^{III} is equal and parallel to OB_3, and the vector B_2B^I is equal and parallel to OB_1.

It is further noticeable that OB_2 is less than either of the currents in the outside lines. It does not always follow that this is true in two-phase, three-wire systems. It is, however, a fact that the current in the middle circuit is always less than the arithmetic sum of the currents in the outside circuits; consequently, for the same percentage of drop, it is always economy to make use of the two-phase, three-wire system wherever possible.

Polyphase systems are often referred to as being either balanced or unbalanced. The two-phase system, which is the subject of the immediately preceding discussion, is "unbalanced." It is unbalanced, for the reason that the electro-motive forces developed by the two generators are not equal, and, further, for the reason that the constants of the "outside" circuits A_1O and OA_3 have different resistance and reactance constants. In a balanced, two-phase system, it is necessary, not only for the electro-motive forces developed by the generator to be separated by an angle of 90 degrees, but, further, that the electro-motive forces developed in the armatures shall be equal, and that the constants of the outside lines shall be identical. If we assume such a condition for the system represented in Fig. 98, r_1 and r_3 must be equal in value, and x_1 must be equal to x_3. As a matter of convenience, we may also make $r_2 = r_1$ and $x_2 = x_1$. Fig. 103 illustrates the effect of these modifications upon the vector diagram pertaining to the system.

That portion of Fig. 103 which is drawn in dotted lines shows the effects produced in the system when one of the two equal generator electro-motive forces is acting alone. If we assume that E_1 is acting, we have the combination of the circuit A_1O connected in series with the circuits OA_2 and OA_3 in parallel. Under present conditions, however, the impedance of each of the three circuits is the same; therefore, the impedance of the circuit A_1O will be equal to twice the impedance of the parallel system represented by the circuits OA_2 and OA_3. That this is true can be readily shown mathematically by applying the principles developed on pages 244 and 300, vol. xxxviii. By equation (151), page 155,

$$z_1 = \sqrt{r_1^2 + x_1^2} = \frac{1}{y_1} \qquad (192)$$

Further, by equation (169), the admittance of the circuit OA_2 equals

$$y_2 = \sqrt{\frac{r_2^2}{(r_2^2 + x_2^2)^2} + \frac{x_2^2}{(r_2^2 + x_2^2)^2}}$$

and the admittance of the circuit OA_3 is

$$y_3 = \sqrt{\frac{r_3^2}{(r_3^2 + x_3^2)} + \frac{x_3^2}{(r_3^2 + x_3^2)^2}} =$$

therefore, the admittance of the circuits OA_2 and OA_3 is

$$y_{2-3} = y_2 + y_3$$

and, consequently, the impedance of the parallel circuits is equal to

$$z_{2-3} = \frac{1}{y_2 + y_3} \qquad (193)$$

Remembering always that $r_1 = r_2 = r_3$, and $x_1 = x_2 = x_3$, and comparing equations (192) and (193), we find that the former has double the value of the latter, since $y_1 = y_2 = y_3$.

In Fig. 103, the electro-motive force E^I acting alone is shown to impress double the voltage upon the circuit A_1O that it impresses upon the parallel circuits. This

is as it should be, in view of the values of the impedances just determined. In each of the branch circuits a current equal to $O'B^{I}_{2-3}$ is set up, and, therefore, since these currents are in phase with one another and with the current in the line A_1O, the current in A_1O will have a value equal to $O'B_1^{I}$ equal to $O'B^{I}_{2-3}$. Since the dotted vector diagram developed on the vector $O'A^{I}$ of Fig. 103 suffices for either of the two electro-motive forces E^{I} and E^{III} acting separately, we can lay off the distance $O'A_3^{III}$ equal to $O'A_1^{I}$ as being the electro-motive force which E^{III} will impress upon the parallel system OA_1 and OA_2 when it is acting alone.

Following out the method of procedure already used in developing the phase diagram of Fig. 102, we can determine the common junction point of the line electro-motive forces by taking the resultant of the vectors $O'A_1^{I}$ and $O'A_3^{III}$. Since $A_1^{I}O$ is drawn from A_1^{I} parallel to $O'A_3^{III}$, the point O locates this junction point; and, therefore, when both E^{I} and E^{III} are acting simultaneously, the electro-motive force which is impressed upon the outside circuit OA_1 will be equal to OA^{I} and also equal to OA^{III}, the electro-motive force impressed upon the outside circuit A_3O. Further, the electro-motive force apparent between the points O and A_2 of Fig. 98 is equal to the vector OO'. In contrast to the vector diagram of Fig. 102, Fig. 103 shows a perfectly symmetrical arrangement of the electro-motive-force vectors. The phase angle between $O'A^{I}$ and OA^{I} is the same as the phase angle between $O'A^{III}$ and OA^{III}, and the vector O'O bisects the angle $A^{I}O'A^{III}$.

When the currents flowing in the several lines are considered, we find that the angle of lag of the current OB_1 behind OA^{I} is equal to the angles of lag of the currents OB_3 and OB_2 behind the vectors OA^{III} and OO' respectively. The phase positions taken by the current vectors are also perfectly symmetrical as regards the electro-motive forces impressed at the terminals of the individual circuits. They are not, however, symmetrical with respect to the electro-motive forces developed in the generator armatures. For instance, as shown in Fig. 103, the current which flows in the armature of alternator E^{I} is represented by the vector OB_1, which lags behind its generator electro-motive force 52 degrees. On the other hand, the current OB_3 flows in the armature of generator E^{III} and is, moreover, in phase with E^{III}. The result of this unsymmetrical disposition of the armature currents relatively to their respective armature electro-motive forces is to throw the burden of the power developed in the circuit chiefly on one of the generators, namely, the generator E^{III}. In the present instance, the load carried by this machine will equal 1.6 times the load carried by the other machine.

If the three circuits, OA_1, OA_2 and OA_3 of Fig. 98 were free of reactance, the three line currents would be in phase with the electro-motive forces impressed at the terminals of the three lines; therefore, OB_1 would be in phase with OA^{I}, OB_3 in phase with OA^{III}, and OB_2 in phase with OO', and the load on the system, as a whole, would be equally divided between the two generators, since the latter condition makes the phase diagram of Fig. 103 entirely symmetrical in all particulars.

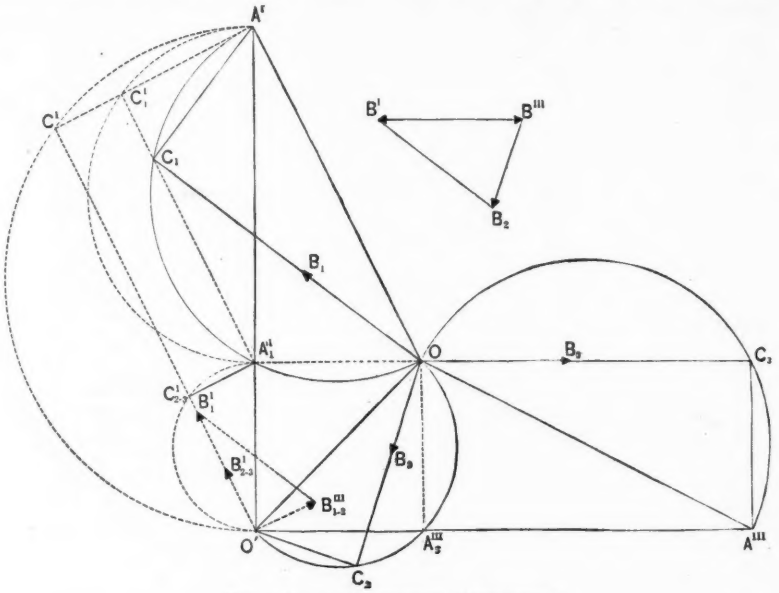


FIG. 103.—ALTERNATING MECHANISMS.

If we make a third assumption to the effect that the reactances of the three circuits are due to capacity effects instead of induction effects, and construct a phase diagram corresponding thereto, the three line currents would be drawn in advance of their respective electro-motive forces. Such a construction would bring OB_1 quite nearly in phase with $O'A^{I}$, while OB_3 would take a position considerably in advance of $O'A^{III}$, and thereby the load would be thrown chiefly on the generator E^{I} instead of the generator E^{III}. We see, then, that such a system as that which is diagrammatically represented in Fig. 98, while excellently adapted for explanatory purposes, is nevertheless one which, practically, would be in rather unstable equilibrium, as slight changes in the values of the line current constants would be apt to cause large oscillations in the loads on the machines. The principles that have been worked out here are exact, but must be modified in a way that will be pointed out later before applying them in commercial practice.

Example 20.

Given: A distributing system such as that illustrated diagrammatically in Fig. 98. Here, the generator E^{I} develops an electro-motive force of 1,200 volts, and the generator E^{III} develops an electro-motive force of 1,000 volts. The two machines are operated synchronously relatively to one another, and the electro-motive force developed by E^{III} machine is given an advance of 90 degrees ahead of the electro-motive force developed by E^{I} machine. The generators are connected in with three distributing lines, so as to form a two-phase, three-wire network. The resistance of the line A_1O is 15 ohms and the reactance is also 15 ohms. The resistance of the line A_2O is 8.3 ohms and its reactance 16.6 ohms, while the resistance of the line A_3O is 22.4 ohms and its reactance 11.2 ohms. The machines operate at 60 cycles per second, and the resistance and reactance of their armatures are neglected.

Determine the values of the currents which are set up in the three lines. The lag of these currents behind the electro-motive forces impressed at their terminals, the phase position assumed by the three currents relatively to the generator electro-motive forces, and, finally, the values of the electro-motive forces impressed at the terminals of each of the three circuits.

To solve this problem, it is necessary to follow the rule stated at the end of Example 19, to wit: The current in each circuit, due to each electro-motive force acting separately, is first found. The final currents which flow in the several parts of the system, when both electro-motive forces are acting together, are equal to the vector sums of the partial currents previously determined as flowing in each line.

Selected Chapters in Electrochemistry.

By Harry C. Jones.

CHAPTER II—THE THEORY OF ELECTROLYTIC DISSOCIATION.

IN THE PRECEDING chapter we saw how osmotic pressure was shown to obey the same laws as gas-pressure, and how Van't Hoff arrived at this generalization, which is one of the most important in modern chemical science.

The conclusion would be drawn from what has been said thus far that the osmotic pressure of all substances conforms to the gas laws. Such is not the case by any means. Indeed, there are a great many exceptions to this law, and, as so frequently happens, the exceptions are as interesting, or even of greater interest, than the cases which conform to the rule.

If we were to study the osmotic pressures exerted by all known substances, we would find that certain classes of compounds exert an *osmotic pressure which was much greater* than that exerted by other classes of substances. Indeed, chemical compounds would divide themselves into two great classes, according to the magnitude of the osmotic pressure which they would exert. The one class would show a pressure which conforms to the gas laws, and which we call normal; the other a pressure which, in some cases, was twice, in others three times, as great. In the former class we should find all those substances like cane sugar, the alcohols, aldehydes, ethers, ketones, etc.; in general, the chemically inactive substances. In the other class we would have the acids, bases and salts; or, in general, those substances which are chemically most active.

A closer examination of the two classes would show that in the former occur all those substances which, when dissolved in water, do not conduct the electric current, and only those; or, in a word, the *non-electrolytes.* In the latter we have all those compounds which, when dissolved in water, conduct the current, and only those, and hence are known as the *electrolytes.*

Van't Hoff recognized clearly these two great classes of substances, which differed widely from one another with respect to the magnitude of the osmotic pressure which they could exert. In the paper to which reference has already been frequently made, he pointed out that many anomalies exist when we try to apply the gas laws to the osmotic pressures of solutions of substances in general, and stated clearly that "examples in aqueous solutions are most of the salts, the strong acids and the strong bases."

Van't Hoff was not able to offer a satisfactory explanation of why the non-electrolytes give osmotic pressures which conform to the gas laws, while electrolytes all exert greater osmotic pressures. This was reserved for another.

ORIGIN OF THE THEORY OF ELECTROLYTIC DISSOCIATION.

The Swedish physicist, Arrhenius, who at that time was working with Ostwald in Leipzig, became interested in the great differences which manifested themselves between non-electrolytes and electrolytes, and especially in the work of, and conclusions reached by, Van't Hoff. Arrhenius pointed out that non-electrolytes differ from electrolytes not only in the osmotic pressures which they exert, but in certain other properties.

It is well known that when a substance is dissolved in a solvent, the freezing point of the latter is lowered; the solution freezing lower than the pure solvent. This is well exemplified in nature in the case of sea-water which freezes lower than pure water. The work of the French Chemist, Raoult,* had shown that the lowering of the freezing point of water produced by non-electrolytes depended only upon the ratio between the number of molecules of the solvent and those of the dissolved substance; *i. e.,* upon the concentration of the solution. Any non-electrolyte lowered the freezing point of water to just the same extent as any other non-electrolyte of comparable concentration, and by comparable concentration is meant the same number of molecules of the dissolved substance in a given volume of the solution.

A molecule of any non-electrolyte produced just the same lowering of the freezing point of a given number of molecules of water as a molecule of any other non-electrolyte.

The electrolytes, however, behave very differently with respect to their power to lower the freezing point of a solvent. *The lowering produced by them was always greater* than that produced by the non-electrolytes. Here we have results similar to those obtained from a study of the osmotic pressures of electrolytes and non-electrolytes. The former exerts a greater osmotic pressure and produces a greater lowering of the freezing point of the solvent than the latter. The agreement between the two sets of phenomena is more than qualitative. We have seen that the electrolytes exert twice, and in some cases three times, the osmotic pressure of non-electrolytes of comparable concentrations. So, here, we find that the electrolytes lower the freezing point of water twice, and in some cases three times as much as the non-electrolytes at comparable concentrations.

The analogies between the properties of the two great classes of chemical compounds are not yet exhausted. It is well known that the presence of a dissolved substance lowers the vapor tension of the solvent. Raoult also showed that non-electrolytes produce the same lowering of the vapor tension of a solvent, if they are present at the same molecular concentration, regardless of the nature of the non-electrolyte. Electrolytes, on the other hand, always produce greater lowering of the vapor tension than non-electrolytes, and, again, in some cases, twice the lowering, and in other cases three times the lowering.

These were some of the facts which had to be dealt with by any theory which would account for the difference between non-electrolytes and electrolytes in solution in water. It is obvious from what has been said that all three of the properties considered—osmotic pressure, lowering of freezing point and lowering of vapor tension—are properties which depend upon numbers only; the magnitude of each and all of them depending, as we have seen, only upon the ratio between the number of molecules of the dissolved substance and the number of molecules of the solvent. If these phenomena depend only upon numbers, and if they have a magnitude greater than would be expected, the only conclusion is that *there are a larger number of parts present than we would expect.*

This is essentially the way the problem presented itself to Arrhenius. We seem, then, forced to the conclusion that in solutions of electrolytes (acids, bases and salts) we have more parts present than would correspond to the molecules of the respective substances. The question naturally arose, how is this possible? A molecule is the simplest unit of a compound of which we can conceive, and yet

*Raoult was Professor of Chemistry at Grenoble, France, where he died a few months ago.

we must have particles in solution which are more numerous than the molecules. The inevitable conclusion is that the molecules themselves must be broken down into parts. But the difficulty was by no means as yet overcome. How could we conceive of the molecules of such substances as hydrochloric acid, potassium hydroxide or potassium chloride breaking down in the presence of water into simpler parts? If a substance like potassium chloride should break down into potassium and chlorine, the potassium would act on water with its well-known vigor, giving potassium hydroxide and hydrogen gas. We know, however, that this is not the case. Potassium chloride dissolved in water does not act chemically at all upon the water; the only change produced being a slight change in temperature, due to the solid passing into solution. We thus seem to be in a hopeless dilemma; phenomena such as we have been considering demanding that the molecules of electrolytes break down in solution, and the nature of electrolytes being such that it seems impossible that any such decompositions could take place.

Arrhenius, however, did not give the problem up, as men less earnest might have done, but went to the literature to see what suggestions had already been made to account for the condition of acids, bases and salts in solution. He found that Williamson had proposed a theory in 1851 to account for the synthesis of ordinary ether from sulphuric acid and alcohol, which stated that in solution the molecules were broken down more or less completely into their constituents, which then recombined forming new molecules. In solution there was, then, a continual interchange of parts going on—a succession of decompositions and recombinations. This did not assist Arrhenius very much, since it left unanswered the question, why do not the parts (say potassium) act chemically upon the solvent water? He was, however, more successful when he turned to a theory which had been proposed in 1856 by Clausius to account for the fact that a very weak current can decompose water. It had been shown that a current which was far too weak to decompose a molecule of water can effect the electrolysis of water to which a small amount of an electrolyte had been added. If the current could not decompose one molecule of water it is obvious that it could not decompose more than one, and yet it caused an appreciable amount of hydrogen to be set free at one pole, and of oxygen at the other pole. To account for this and similar facts, Clausius assumed that some few of the molecules of water are already decomposed before the current is passed—decomposed not into atoms, but into atoms which were charged with electricity—the one positive and the other negative, and called *ions. An ion is, therefore, a charged atom or group of atoms.*

This gave Arrhenius the clue to the explanation of such phenomena as we have been considering. The electrolytes gave abnormally large osmotic pressure, abnormally great depression of the freezing point, and abnormally great depression of the vapor tension of the solvent, because their molecules were broken down into ions. The ions being atoms or groups of atoms charged with electricity, differed fundamentally in properties from the same atoms or groups when uncharged, and, consequently, the difficulty that substances like potassium chloride could not break down into its constituents in the presence of water, because potassium in the atomic or molecular condition acts so vigorously upon water, was overcome. The ion of potassium has, necessarily, no property in common with the atom of potassium except that of mass, which remains unchanged when the atom becomes an ion. *Thus arose the theory of electrolytic dissociation,* in the hands of Arrhenius.

It might, however, be concluded from what has been said that Arrhenius did nothing more than take the suggestion which had been made by Clausius and apply it to these newly discovered phenomena, but such is not the case. The suggestion which had been made by Clausius was purely qualitative. It simply stated that in water there are a *few* molecules broken down into ions. It did not say what percentage of the molecules is broken down into ions, and Clausius did not point out any method by which this could be determined.

Arrhenius took this purely qualitative suggestion of Clausius and converted it into a quantitative theory by pointing out methods by which the amount of dissociation could be measured. If the theory was true the amount of dissociation, as measured by the different methods, must agree. If different methods gave different results, it would be a very strong argument against the correctness of the theory of electrolytic dissociation. We shall turn now to this phase of the problem.

Testing the Theory of Electrolytic Dissociation—In his original paper,* which has now become a classic, Arrhenius not only proposed the theory of electrolytic dissociation, but pointed out methods by which its truth could be tested. If this is to become a general theory of solution, it must not only account for the abnormally large osmotic pressure exerted by electrolytes, but also for the abnormally large freezing point lowering, and lowering of vapor tension produced by these substances. If we reverse the line of reasoning and measure the amount of dissociation by the abnormally large osmotic pressure exerted by the electrolytes, we should obtain exactly the same result as when we measured the dissociation by the abnormally large lowering of freezing point, or abnormally large lowering of vapor tension produced by these substances. Arrhenius applied just this test to his theory. He measured dissociation, on the one hand, by the lowering of freezing point produced, and, on the other, by the osmotic pressure which was exerted by the electrolytes, and compared the two sets of values obtained.

This matter is of such great historical importance in connection with the development of the whole theory of electrolytic dissociation that it must be considered in some detail. The fundamental principle underlying the deduction of Arrhenius is that an ion exerts exactly the same osmotic pressure as a molecule, and produces the same lowering of the freezing point and of the vapor tension of a solvent as a molecule. This follows from the fact, which has already been pointed out, that these phenomena depend only upon numbers, and since ions are independent individuals, their influence on the properties is exactly the same as molecules.

Since we can deal with ions and molecules indiscriminately in connection with these properties, the calculation of the percentage dissociation by means of osmotic pressure or freezing point lowering becomes very simple. Suppose we are dealing with a binary electrolyte; *i. e.,* with one which dissociates into two ions. If it is not dissociated at all it will exert the same osmotic pressure, and produce the same lowering of the freezing point as a non-electrolyte of the same concentration. If it is completely dissociated it will produce twice this osmotic pressure and lowering of freezing point. If it is partly dissociated it will produce an osmotic pressure and lowering of freezing point which lies somewhere between these values. By simple proportion, then, we obtain at once the amount of dissociation, knowing the osmotic pressure or the lowering of the freezing point exerted by the substance.

Arrhenius proceeded as follows: The

* On the Dissociation of Substances Dissolved in Water. *Ztschr. phys Chem.* I, 631. Translated into English by H. C. Jones, *Harper's Science Series,* iv, p. 47.

lowering of the freezing point of water produced by a gram-molecular weight of a non-electrolyte in a litre of solution is 1°.86. Such a solution is, of course, a normal solution, as this expression is used in chemistry; and the quantity, 1°.86, is known as the molecular lowering of the freezing point of water, or the freezing point constant of water. If the freezing point lowering actually observed for the electrolyte of normal concentration is t°, the ratio between these two does not give the dissociation, but gives a coefficient i, which, from its discoverer, has come to be known as the Van't Hoff i. From the freezing point lowering, then, $i = \frac{t^\circ}{1^\circ.86}$. The dissociation a is obtained at once from the coefficient i. For a binary electrolyte $a = i - 1$; for a ternary electrolyte, $a = \frac{i-1}{2}$.

Arrhenius then calculated the value of i from osmotic pressure, as follows: If we represent by m the number of undissociated molecules present, by n the number of dissociated molecules, and by k the number of ions into which each molecule dissociates, we have

$$i = \frac{m + kn}{m + n}.$$

The values of i were thus calculated by two entirely different methods; it now remained to see whether the two sets of values agreed with each other, or whether they did not. If there was an agreement it was a strong argument in favor of the correctness of the new theory; if there was not an agreement it would be very unfortunate for the theory. A very few* of the results which were obtained by Arrhenius for acids, bases and salts are given below:

	i from Freezing Point Lowering.	i from Osmotic Pressure.
ACIDS.		
Hydrochloric acid....	1.98	1.90
Nitric "	1.94	1.92
Sulphuric "	2.06	2 19
Farmic " ...	1.04	1.03
Malic "	1.08	1.07
BASES.		
Potassium hydroxide.	1.91	1.93
Sodium "	1.96	1.88
Barium "	2.69	2.67
Calcium "	2.59	2.59
Ammonium "	1.08	1.01
SALTS.		
Potassium chloride....	1.82	1.86
Sodium " ...	1.90	1.82
Ammonium "	1.88	1.84
Sodium nitrate.....	1.82	1.82
Potassium acetate....	1.86	1 83
Sodium carbonate ...	2.18	2.22
Strontium nitrate.....	2.23	2.23
Lead nitrate.....	2.02	2.08
Cupric acetate.....	1.68	1.66

These comparisons were made for about 15 bases, 23 acids and 40 salts, and while some apparent discrepancies appeared, still, an unmistakeable agreement existed in the two sets of values.

Almost as quickly as these agreements were pointed out for so many electrolytes the theory began to attract attention. Here were facts which, from their nature, could not be disregarded, and from their number could not be referred to accident. There must be a large element of truth in any generalization which accorded so well with so much experimental data. This seems to be about the way in which the whole subject presented itself to the more progressive men some 14 years ago, when the paper by Arrhenius appeared. They saw in this theory a generalization which was capable of accounting for a large number of facts which, before it was proposed, were entirely inexplicable in terms of any conception known at that time.

The theory of electrolytic dissociation, like all wide-reaching generalizations, was fortunate in that it did not escape criticism from conservative hands. I do not refer to that kind of criticism which is based upon a lack of familiarity with the facts involved, and which was poured out in abundance against this theory for a time from certain quarters; but to legitimate criticism, based upon real difficulties encountered when an honest attempt was made to apply it to certain classes of facts—a criticism based upon an earnest desire to arrive at the truth. I have referred to this kind of criticism as fortunate, since it puts a theory upon its mettle, as it were, and sifts the wheat from the chaff. If the theory has any value it will be brought out, or, if it is inherently incapable and worthless, it will be overthrown before it has done any harm to the advance of science. It was such criticism as this that made the supporters of the new view look around for evidence bearing upon it. A few of the many lines of evidence bearing upon the theory of electrolytic dissociation will now be taken up.

Further Lines of Evidence Bearing upon the Theory of Electrolytic Dissociation*—The theory of electrolytic dissociation says that acids, bases and salts in the presence of water are broken down into their ions, the amount of the dissociation of any compound depending chiefly upon the concentration of the solution. As the dilution increases the percentage dissociation increases, until at a dilution of about 1,000 litres,* the strong acids and bases, and the salts in general, are completely dissociated. These substances, at this dilution, exist, then, only in the ionic condition, there being no molecules present.

It is obvious that the properties of such solutions of these substances must be the properties of the ions present, and not those of the molecules, since there are no molecules in the solution. This applies to all the properties of such solutions, both physical and chemical. We have in this fact a means of testing the correctness of our theory, as we shall now see.

Let us take up certain properties of completely dissociated solutions and see whether they are additive; *i. e.*, the sum of the corresponding properties of the ions which are present. We shall consider first the *specific gravity of solutions of certain salts.*†

"If a salt is added to water, the volume of the solution is different from that of the pure solvent, and also from the sum of the volumes of the liquid and of the solid. If the resulting solution is very dilute, the salt is completely dissociated into its ions. Nernst has shown from the results of J. Traube that the change in volume, under such conditions, is an additive property of the ions. Given a solution containing a gram-molecular weight of a salt whose molecular weight is M, in m grams of water. Let the specific gravity of the solution be S, the specific gravity of water s. *The change in volume* $\triangle v$, on dissolving the salt, will be:

$$\triangle v = \frac{M + m}{S} - \frac{m}{s}.$$

"The following results are given:

KCl = 26.7	NaCl = 17.7
KBr = 35.1	NaBr = 26.7
KI = 45 4	NaI = 36.1
KBr − KCl = 8.4	KI − KBr = 10.3
NaBr − NaCl = 9.0	NaI − NaBr = 9.4
KI − KCl = 18.7	KCl − NaCl = 9.0
NaI − NaCl = 18.4	KBr − NaBr = 8.4
	KI − NaI = 9.3

"These results show the additive nature of the specific gravity of salt solutions. The difference between the chlorine and the bromine ions is about 8.7; between chlorine and iodine, 18.5; between bromine and iodine, 9.8; while between potassium and sodium it is about 9.0.

"The additive nature of the specific gravity of salt solutions had, indeed, been pointed out much earlier by Valson. He had shown exactly what is brought out above: Given salt solutions of comparable

* For a fuller discussion of this subject with the results which were obtained, see Theory of Electrolytic Dissociation (H. C. Jones), pp. 98-100.

* The few lines of evidence for this theory, which will be considered in the remainder of this chapter, are discussed more fully, and many other lines are taken up in my book, to which reference has already been made. Theory of Electrolytic Dissociation. (Macmillans)

* This means a solution which contains a gram-molecular weight of the electrolyte in 1,000 litres of the solution.

† This paragraph is quoted from my book on the Theory of Electrolytic Dissociation, p. 105.

concentration; *i. e.*, containing, say, a gram molecule of the salt per litre, the difference between the specific gravities of solutions containing two metals combined with the same acid is constant, whatever the nature of the acid. Similarly, the difference between the specific gravities of two salts of the same acid with any metal is constant, regardless of the nature of the metal. The specific gravity of a salt solution is then obtained by adding to a constant number two values—the one for the acid, the other for the metal. These values Valson termed 'moduli'; and he worked out their values for a large number of elements.

"Valson concluded from his work that the molecules of salts must be completely broken down in solution. But the evidence in favor of such a view was not strong enough at that time to bring it into favor."

One other property of solutions of salts will be considered in this connection, that it may be seen that the above relations are not merely accidental. When acids and bases neutralize one another, a change in volume is produced. If a litre of a normal solution of a univalent acid is brought together with a litre of a normal solution of a univalent base, the resulting volume is not two litres, but somewhat less, there being, in general, a contraction in volume.*

"*The change of volume* produced by neutralizing acids with bases has been extensively studied by Ostwald. The solutions contained a gram equivalent of the acid or base, in a kilogram, and were, therefore, not completely dissociated; so that, if the change in volume was additive, it would be shown only approximately by such solutions.

"Ostwald worked with 19 acids, including the strongest mineral acids, and some of the more strongly dissociated organic acids. He neutralized these with the three bases, potassium, sodium and ammonium. A few of his results are given, the change in volume being expressed in cubic centimetres. The differences in the horizontal lines are the differences between potassium, sodium and ammonium, in combination with the same acid. The differences in the vertical columns are the differences between the different acids in combination with the same bases, obtained by subtracting the value for the acid from the value for nitric acid.

	Potassium Hydroxide.	Sodium Hydroxide.	Ammonium Hydroxide.
Nitric acid,	20.05 (0,28)	19.77 (26.21)	—6.44 (26.49)
	(0 53)	(0.53)	(0.13)
Hydrochloric acid,	19.52 (0.28)	19.24 (25.81)	—6.57(26.09)
	(7.69)	(7.61)	(7.15)
Formic acid,	12.86 (0.30)	12.16 (25.75)	—13.59 (25.95)
	(10.53)	(10.49)	(9.82)
Acetic acid,	9.52 (0.24)	9.28 (25.54)	—16.26 (25.78)
	(8.15)	(8.29)	(7.91)
Sulphuric acid.	11.90 (0.42)	11.48 (25.83)	—14.35 (26.25)
	(11.82)	(11.84)	(11.19)
Succinic acid,	8.23 (0.30)	7.93 (25.56)	—17.63 (25.86)

" If we take the perpendicular rows in parentheses we find very nearly a constant difference for the strong acids and bases. Similarly, if we take the horizontal rows in parentheses, we find very nearly a constant difference. This means that the difference in change of volume, produced by neutralizing two different bases by a given acid, is a constant, independent of the nature of the acid; and, similarly, the difference of the change in volume on neutralizing two different acids by a given base is independent of the nature of the base.

"The change in volume, when acids and bases neutralize each other, like the specific gravity of salt solutions, is, then, an additive property, depending both upon the nature of the acid and of the base; and we could work out here, as Valson has done in the case of specific gravities, the numerical values of the constants for each constituent."

A number of other physical properties of solutions of completely dissociated substances have been studied in a manner analogous to the above, with the result that they have been shown, in general, to be the sum of two constants, the one depending upon one ion, and the other upon the other ion. We should mention, especially, the *color of solutions* of completely dissociated substances. Ostwald has carried out an elaborate study of this property of solutions of about 300 colored substances. Only a few of his results will be considered here, and we will take up one of the best known and simplest cases—the permanganates. The permanganates all dissociate in a manner analogous to potassium permanganate:

$$KMnO_4 = K + MnO_4.$$

The potassium ion is not colored, since it exists in solutions of potassium chloride, nitrate, sulphate, etc., and these solutions are colorless. The color of such solutions must be due, then, entirely to the presence of the MnO_4 ion.

This same line of reasoning holds for all permanganates in which the metal is colorless. The color of the solutions of these salts must be due entirely to the presence of the ion of permanganic acid, MnO_4. The conclusion is that the color of solutions of all the permanganates, in which the metal is colorless, must be the same. This was studied by Ostwald, who determined the absorption spectra of solutions of ten or a dozen such permanganates, and found that the absorption bands of all of them fell at exactly the same places in the spectroscope. The positions of these bands were measured, and they were also photographed and compared by superposition. The general result was just what would be expected if our theory were true—the colors of the different permanganates are exactly the same, and further, the same as that of permanganic acid itself, which dissociates into MnO_4 and hydrogen, and the latter ion is known to be colorless since solutions of acids like hydrochloric, nitric, sulphuric, etc., in which an abundance of hydrogen ions are present, are colorless.

The conclusion from the study of the color of solutions, like that from the study of other physical properties, is in perfect accord with the theory of electrolytic dissociation, and it is very difficult to see how these facts could be interpreted if this generalization had not been reached.

Evidence has been obtained for the correctness of the theory of electrolytic dissociation from a study of the *properties of mixtures* of substances. We shall take first a mixture of substances which are readily dissociated, and then a mixture of substances which are not dissociated at all. Let us take a mixture of potassium nitrate and sodium iodide, and make a very dilute solution of the mixture. Since both salts are readily dissociated at moderate dilutions, we would have them both completely broken down into their ions, thus:

$$K + NO_3 + Na + I.$$

The properties of the mixture, both chemical and physical, would be the sum of the properties of these four ions.

If now we mix potassium iodide and sodium nitrate and make a dilute solution of the mixture, we would have both salts completely dissociated into their ions, which would be:

$$K + I + Na + NO_3.$$

In terms of our theory, we would have exactly the same ions in the two cases, and the properties of the two mixtures should be identical. Such is the fact. The two mixtures referred to above, using equivalent quantities of the different substances, are, in every respect, identical.

If, on the other hand, we mix two substances which are not dissociated to any appreciable extent by water, and dissolve the mixture, we would have different solutions, according to the theory, depending upon which substances were combined at the outset. Thus, a mixture of methyl alcohol and ethyl chloride would have properties which were the sum of the

* The following paragraph is quoted from Theory of Electrolytic Dissociation. (Macmillan's.)

properties of the molecules CH_3OH and C_2H_5Cl. The properties of a mixture of ethyl alcohol and methyl chloride would be the sum of the properties of the molecules C_2H_5OH and CH_3Cl. Since, in the two mixtures the molecules are different, the properties of the two mixtures should be different. Here, again, facts and theory are in perfect agreement. The two mixtures have very different properties.

It is not easy to lay too much stress upon these facts as bearing upon the general correctness of the theory of electrolytic dissociation. Without this theory such facts would be entirely inexplicable; with it they are just what we would expect. One could scarcely wish for stronger arguments in favor of the general truth of the theory of electrolytic dissociation.

An Experimental Demonstration of Dissociation—This chapter should not be concluded without reference to a very simple experiment, which demonstrates to the eye the dissociating action of a solvent like water. If a few drops of an alcoholic solution of phenolphthalein are added to a cylinder containing, say, 100 c.c. of alcohol, and a drop of aqueous ammonia added and the cylinder shaken, there will be no trace of the purple color which is characteristic of this indicator in the presence of alkalies. If, now, water is added to the alcohol, the purple color will begin to appear, and will become deeper and deeper as more and more water is added.

The explanation of what takes place is comparatively simple. Ammonia is a base which is dissociated only slightly, even by so strong a dissociating agent as water. By alcohol it is scarcely dissociated at all. In order that a base may react with phenolphthalein it must be dissociated to some extent. Ammonia in alcohol does not react alkaline with phenolphthalein, because it is not sufficiently dissociated. If, now, water is added, this dissociates the ammonia, and we have our indicator showing its characteristic alkaline reaction. If more alcohol is added the dissociation of the ammonia is driven back, as we say, and the color disappears.

We have thus a demonstration to the eye of the dissociating action of water, expressing itself in the color of the phenolphthalein.

This demonstration becomes still more instructive if we carry out in addition the following experiment. Let us proceed exactly as described above, using a drop of an aqueous solution of potassium hydroxide instead of ammonium hydroxide. As soon as the potassium hydroxide is added to the alcohol containing phenolphthalein, the purple color appears without the addition of water. This fact was also predicted by us* from the theory before the experiment was tried. Potassium hydroxide is a strongly dissociated base, and is sufficiently dissociated even by alcohol to show the alkaline reaction with phenolphthalein.†

We have thus presented a very little of the enormous mass of evidence bearing upon the theory of electrolytic dissociation. While certain facts are known which have given some difficulty when an attempt was made to fit them in with the theory, the great preponderance of evidences points to its general correctness. It should be said that as experimental work is more and more carefully done, the number of apparent exceptions to the theory becomes rather less than more; so that while we should always welcome real exceptions to the theory, we should not be in too great a hurry to accept apparent discrepancies until they have been thoroughly tested by experiment.‡

Accepting the theory of electrolytic dissociation as a most fruitful working hypothesis, we shall consider in the next chapter some applications which have been made of it.

Ammonium Perchlorate.

A new electrolytic process for manufacturing this salt has been patented in Germany, says an English contemporary. The starting point of the new method is calcium perchlorate, instead of the usual sodium perchlorate. This salt is made to react with sal ammoniac in concentrated solution, and the ammonium perchlorate resulting from the double decomposition is obtained as a precipitate. The calcium chloride remains in solution and can be separated by filtration. The calcium chloride serves by electrolysis in the more usual way for the regeneration of the calcium perchlorate. Fifty-five pounds of calcium chloride are electrolytically converted in dilute solution into perchlorate. The solution of the latter is evaporated down, mixed with a warm concentrated solution of 54 pounds of sal ammoniac. The precipitate is filtered off, and the filtrate again converted into calcium perchlorate. Magnesium chloride can also be used.

* Jones and Allen; *American Chemical Journal*, xviii, 377.

† For a fuller explanation of this experiment, see Theory of Electrolytic Dissociation, pp. 113-115.

‡ An account of some apparent exceptions, which have been shown to be due entirely to experimental error, will soon be published in the *American Chemical Journal*.

New Zealand-Australian Cable.

Mr. J. G. Ward, minister of railways and telegraphs for New Zealand, asserted during the late visit of the Duke of York to his country that a cable between Australia and New Zealand, built and operated by the government, would mean a saving of 70 per cent in cable tolls. Mr. Ward makes the charge that the rates now fixed by the cable companies are exorbitant, and under a scheme for government ownership which he proposes shortly to introduce, he expects to reduce the cost of cabling to England by one-third.

London Underground Railways.

The British Joint Parliamentary Committee is considering the claims of several companies which have asked for franchises to construct underground railways in London. The total mileage represented in these schemes is a fraction over 42 miles, while the proposed capital is $96,130,000. These proposed roads are not included in the 11 schemes already authorized by Parliament for the construction of 52 miles of underground railway with a capital of $159,500,000.

Electric Heating for Acid Concentration.

A French contemporary states that in the concentration of sulphuric acid a source of heat consisting of a platinum wire electrically heated has been used with good results. The wire used was 0.2 inch in diameter and 30 inches long, and was brought to a temperature of 480 degrees. Fifty-five pounds of acid were concentrated per day. To make 100 kilogrammes (62 pounds) of 66-degree acid it requires a little over 44 horse-power-hours.

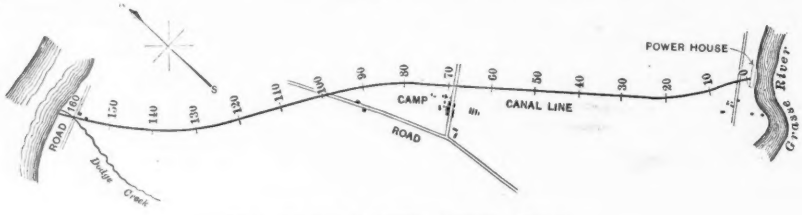
Unusually large electric light plants will be installed in the two gigantic steamships which are now being built at New London, Ct., at a cost of $2,500,000 each for the Great Northern Railway. Five 75-kilowatt machines will be fitted in each vessel. The power of the engines driving the dynamo alone will be 700 horse-power, and the engines driving the induced draft fans will produce 400 horse-power.

The United States is not only the greatest user of copper, but is also the greatest producer. In 1899 our production of this metal amounted to 567,500,000 pounds, as against the total production by all other countries of 489,351,000 pounds. Our exportation of copper for the year 1900 amounted to 381,000,000 pounds. We shall probably mine 600,000,000 pounds in the United States during the year.

The Massena Power Development.

Progress of Work on the Great Power Plant of the St. Lawrence Power Company at Massena, N. Y.

WORK on the great hydraulic and electric power installation which the St. Lawrence Power Company is erecting at Massena, N. Y., is now nearly finished. This enterprise has enlisted no little attention since its inception and the progress of work on it has been watched by both electrical and hydraulic engineers on account of the extraordinary magnitude of the work itself and the interest which attaches to power developments on so large a scale.



PLAN OF THE MASSENA POWER CANAL.

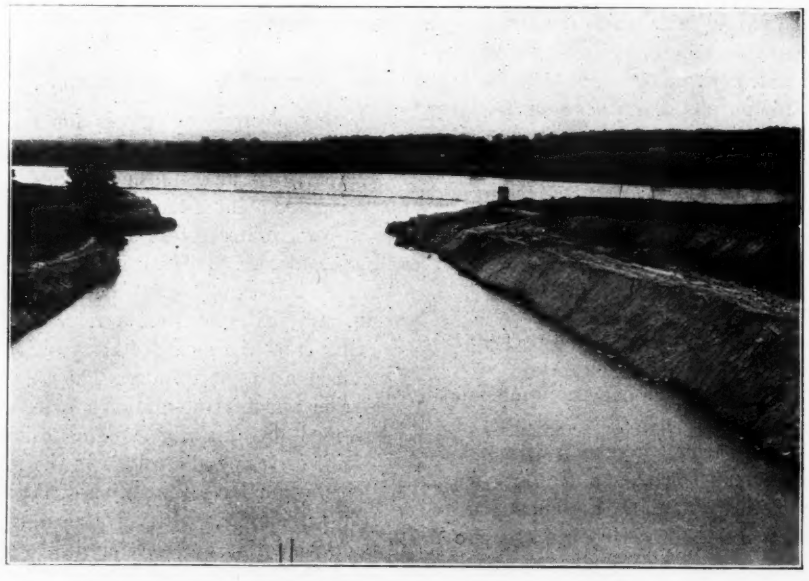
In brief, the development consists of the utilization of a curious natural conformation of territory by which the Grasse River, a tributary of the St. Lawrence, runs parallel with the larger stream and at a short distance from it, yet no less that 42 feet below it at a point about nine miles above the confluence of the two streams. This difference in level is accounted for by the fact that the Grasse River is a stream of slow current in which the water gradient is not very great, while the St. Lawrence, in the part near Massena, descends rapidly by the Long Sault Rapids. The distance from river to river near the town of Massena is only 16,200 feet, a little more than three miles, and for the whole of this distance the level of the country is slightly above that of the water in the St. Lawrence above the rapids. Hence all that was necessary to do to create an artificial waterfall of great power was to build a canal from the St. Lawrence to the Grasse River and erect a power-house upon the shore of the latter.

The work of constructing the canal and the power-house, and of developing an estimated total of 150,000 horse-power was undertaken by the St. Lawrence Power Company, a corporation having its headquarters in London. The actual work of construction has been done by a construction company, the excavation and most of the hydraulic and other work having been done by the T. A. Gillespie Company, of New York. In the ELECTRICAL REVIEW for October 24, 1900, a complete description of the plant as it stood at that time was given. This paper proposes to deal with the present condition of the work which has so nearly advanced toward completion as to indicate very fully its appearance when in operation.

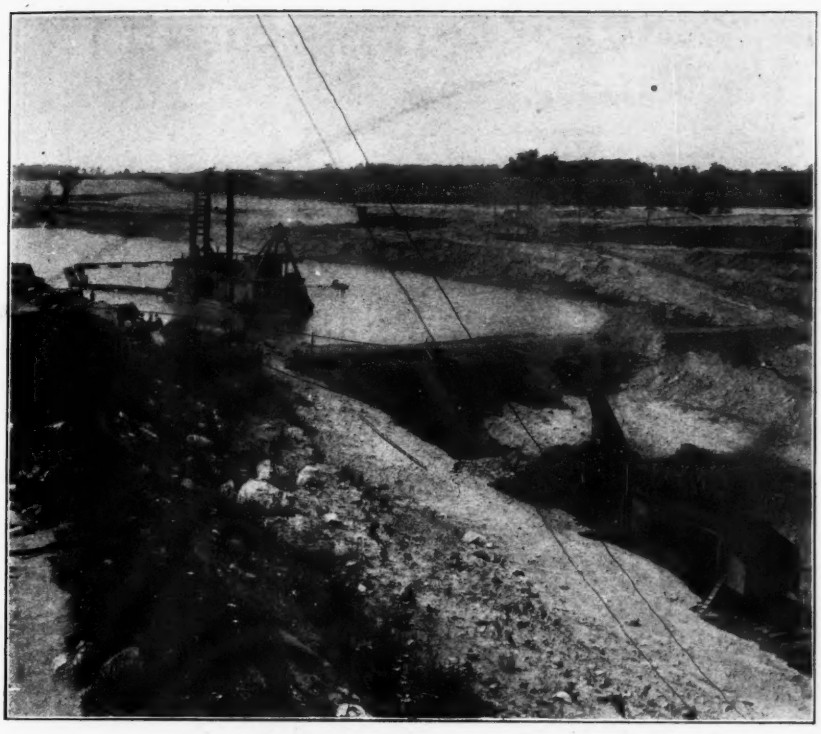
The canal is the largest work of its kind, so far as its area of cross-section is concerned, that has ever been undertaken. The normal depth of water in it is 27 feet and the flat bottom is 187.5 feet wide. The banks of the submerged portion are built at a slope of one and one-half to one, making the width at the water-level 262.5 feet. On account of the configuration of the country no embankments were required, the whole canal having been excavated. The deepest cutting, at a point about the middle of the canal, is known as the Andrews Ridge cut, and is about 95 feet deep in all. A velocity of flow in the canal of 13½ miles per hour is secured by a water gradient of six and three-quarter feet per 1,000. At the power-house, on the Grasse River, the available head is about 32 feet, and here the canal is enlarged in width to form a forebay and to reduce the velocity of the water entering the turbines.

Some of the accompanying illustrations show the last work of the excavation of the canal. At present about 90 per cent of the total excavation has been finished and water could immediately be let back to the power-house, were this desirable. A few pieces of earth have been left across the canal section to be removed as a last measure, this being the case particularly at the Andrews Ridge cut, where some steam shovels are still at work. One of these is well shown in one of the accompanying illustrations.

Another illustration shows an interesting combination of steam shovel work on a lower level, and hydraulic dredge work on an upper level, separated only by a narrow space of earth. Hydraulic dredges of the type illustrated, in which a boring head loosens the earth which is mixed with water and forced out through pipes in a semi-fluid condition, have been found exceedingly applicable to this work on account of the character of the clayey soil encountered. In some cases their value was so great that water was actually pumped to form an artificial basin for them to work in on an upper level of the canal. The pumping engines on these dredges are of the centrifugal type, direct-coupled with a 125-horse-power steam engine of the compound condensing variety.



THE INTAKE OF THE POWER CANAL ON THE ST. LAWRENCE RIVER.



HYDRAULIC DREDGE AND STEAM SHOVEL IN CANAL CUT.

It maintains a 25-inch vacuum in the suction pipe and can work against a delivery head of as much as 60 feet. The usual work of the dredges, which were built by the Morris Machine Works, of Baldwinsville, N. Y., has been 1,000 cubic yards in 20 hours of work per day.

The power-house is built entirely of concrete, this having been made from the stone excavated from its site and near-by. Fortune seems to have favored this project in placing stone where it was convenient for the power-house foundation, and nowhere else along the line of work. In order to secure the necessary space for the operations a cableway was constructed across the Grasse River to a stone-yard on the opposite side from the power-house, and over this all of the materials excavated were sent, the rock being crushed and the concrete mixed on that side and sent back over the cableway to be put in place on the work.

The power-house itself is so well shown in the accompanying illustrations as hardly to require further description. The building closes the Grasse River end of the power canal, and is 633 by 147 feet in ground plan. About 30,000 cubic yards of concrete were used in the construction of the building and the other works at the end of the canal. When the contemplated plant is fully complete this building will contain the largest aggregate of power-generating machinery in the world, its destined equipment being thirty 5,000-horse-power units. At present there are seven units in course of installation, the view of the interior of the building showing excellently the present condition of the power-house. All of the material is at hand and the work of installing the large generators is progressing with great rapidity. All of the hydraulic machinery is already in place. The turbine units for driving the dynamos each consist of six 54-inch Victor wheels, installed tandem on a horizontal shaft which is direct-coupled with the dynamo shaft. Three draft tubes are connected with these six wheels, which are submerged, the draft tubes being of steel, and 10 feet in diameter. The horizontal shaft, which is 12½ feet in diameter, passes through a water-tight journal 30 inches long in a steel plate closing one end of the chamber in which the wheels are submerged, and thence to the coupling connected with the dynamo. Each wheel generates 1,000 horse-power, and each shaft has delivered to it 6,000 horse-power at the normal speed of 150 revolutions per minute.

The dynamos are of the revolving field external armature type and generate three-phase currents at 50 cycles and 2,200 volts in each phase. The revolving field has 20 poles, and the armature winding has 12 slots per pole per phase. Each of these machines is constructed to deliver a normal output of 3,750 kilowatts and a maximum capacity of 5,500 kilowatts with a full-load efficiency of 96 per cent and heating not to exceed 36 degrees above the atmospheric temperature under normal conditions of operation. The size of

STEAM SHOVELS IN THE ANDREWS CUT, MASSENA POWER CANAL.

EXTERIOR AND INTERIOR VIEWS OF THE MASSENA POWER-HOUSE, JULY 25, 1901.

EASTERN END OF THE MASSENA POWER-HOUSE.

the dynamos may well be appreciated from the fact that each bearing is 16 inches in diameter and 65 inches long.

For excitation there are at present in course of installation three 300-kilowatt, direct-current, 125-volt machines, each direct-coupled to a Victor turbine of 27 inches diameter. These units run at a normal speed of 275 revolutions per minute. All of the electrical machinery was manufactured by the Westinghouse Electric and Manufacturing Company, of Pittsburgh.

The main switchboard for handling the output of the large generators will be operated by compressed air controlled by electric switches from a central gallery, where supervision may be had over the entire plant. All of the measuring and controlling apparatus will be gathered in this gallery, except the totalizing wattmeters on the various outgoing leads. The bus-bars are in duplicate and each machine is connected with the board by two three-conductor cables run in ducts under the floor. A gallery above the switchboard gallery will take care of the feeder wires, which go out of the building at each end and thence to underground distributing point, whence the circuits go either underground or overhead as may be desirable for the various services rendered.

Should any haste arise for the completion of the plant it can be in full operation by the middle of October next, though it is not at present contemplated turning over the machines until somewhat later than that time. It is believed that the large majority, if not all, of the power generated will be utilized in the immediate vicinity of Massena itself. The town, while at present practically devoid of manufacturing industries, is a conveniently situated shipping point and easily accessible for many of the crude materials of manufacture. In its vicinity are found excellent beds of clay, while St. Lawrence County, in which the town is situated, is noted for many mineral products. The canal itself gives access by the St. Lawrence and lake system of navigation to the interior of the country and to deep water *via* the Gulf of St. Lawrence. No less than three railroad systems are in immediate proximity to the plant, the company having constructed a spur track with heavy bridges over the Grasse and Racquette rivers to the power-house, which connects that point with both American and Canadian systems of railways.

STEAM SHOVEL AND INCLINE WORKING IN THE ANDREWS CUT ON THE MASSENA POWER CANAL

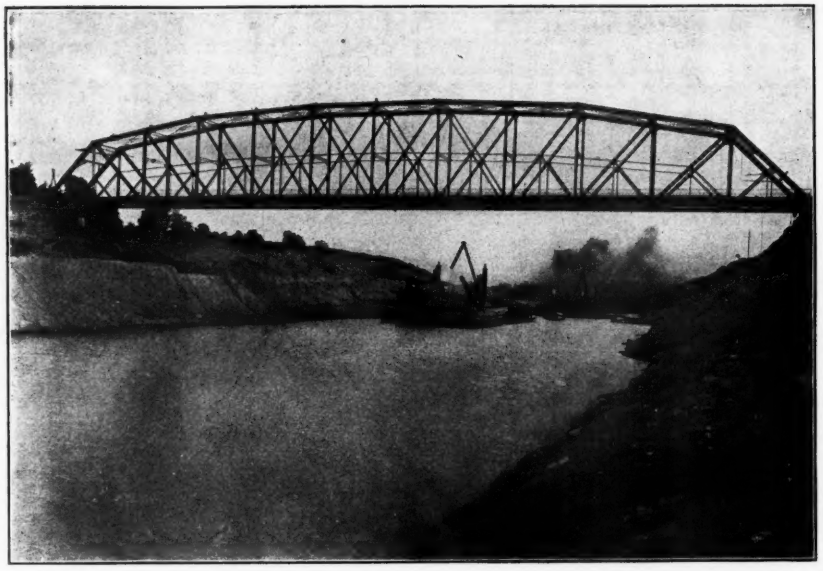
French Visitors at the Institute Summer Meeting.

A considerable number of French electrical engineers will visit this country during the month of August, and it is expected that a party of them will join the American Institute of Electrical Engineers at its summer meeting and journey to Buffalo. The French journal, *L'Eclairage Electrique,* has organized a tour for a technical party which will leave Paris August 3. The party will arrive on one of the French line steamships, at New York, on Sunday, August 11, and will leave the same evening for Philadelphia. Monday and Tuesday will be spent in that city, the party returning to New York Tuesday evening. On Wednesday, August 14, the party will stay in New York, meeting with the American Institute of Electrical Engineers and going up Sunday, the 18th, by steamboat on the Hudson River, to Albany. Monday will be spent at the General Electrical Company's works, at Schenectady, and, on a special train, going to Buffalo the same evening. Tuesday to Sunday, August 20 to 25, will be spent at the Pan-American Exposition and Niagara Falls, in company with the institute which meets there at the same time. The party will then go down the St. Lawrence River to Montreal, thence to Quebec, returning to New York *via* Lake Champlain, and thence to Paris. Plans for the reception and entertainment of the French guests are under consideration by the officers of the institute.

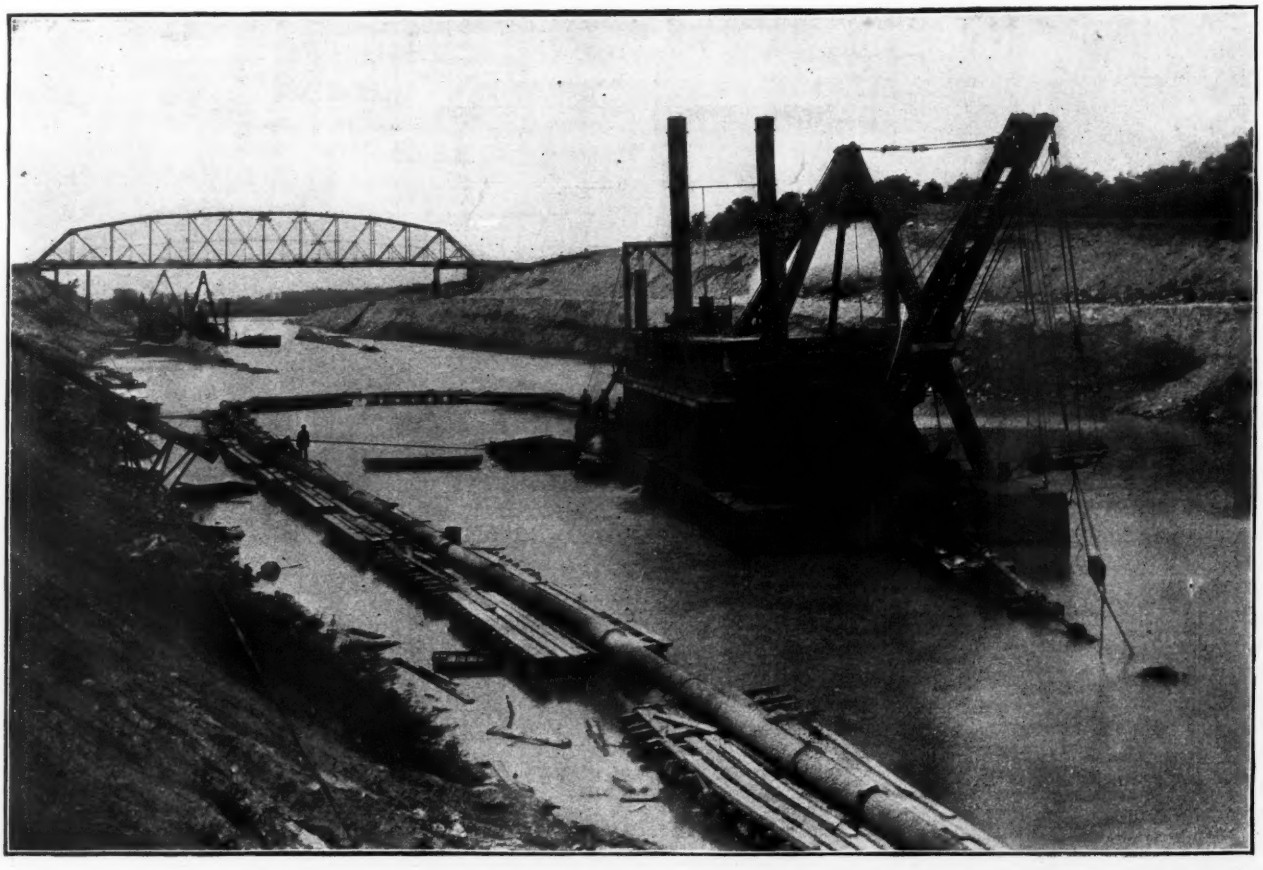
Mr. Hubbell Made President of Two Large Telephone Organizations.

Mr. B. G. Hubbell, who has been an active organizer of telephone exchanges for many years, has recently been elected president of the Consolidated Telephone, Telegraph and Cable Company of America, and of the Interocean Telephone and Telegraph Company. These companies were incorporated a short time ago, the first with a capital stock of $10,000,000, under the laws of Delaware, and the latter with a capital of $2,000,000, under the laws of New York. At the meeting a plan of action was outlined and the interest of the Century Telephone Construction Company, of which Mr. Hubbell is president, and which has been operating independent exchanges in western New York state and building long-distance telephone lines for more than a year, were formally transferred to the Interocean Telephone and Telegraph Company. The two new companies will work in harmony with the Telephone, Telegraph and Cable Company of America, according to reports, and it is planned to control the independent telephone interests west of New York city and east of the territory of the Federal Telephone Company. The board of directors of the Interocean company is as follows: W. H. Price, president of the City Trust Company; R. N. Parmely, president of the American Exchange Bank; J. H. Fuller, of the Stone-Fuller Company; Luther Allen, president of the Bankers' National Bank; C. H. Stewart, secretary of the Euclid Avenue Trust and Savings Company; E. G. Tillotson, secretary and treasurer of the Cleveland Trust Company; H. D. Critchfield, general counsel of the Federal Telephone Company; K. F. Gill and B. G. Hubbell.

Much interest is attached to these new organizations, as Mr. Hubbell has been for many months quietly developing the telephone interests of western New York state and has in the neighborhood of 25 smaller companies under his control. Mr. Hubbell is a man considerably under forty, and has devoted his career to the progress of telephony, and is recognized as an able organizer and financier.



Road Bridge Across the Massena Power Canal.



Hydraulic Dredge Working near the Intake of the Massena Power Canal.

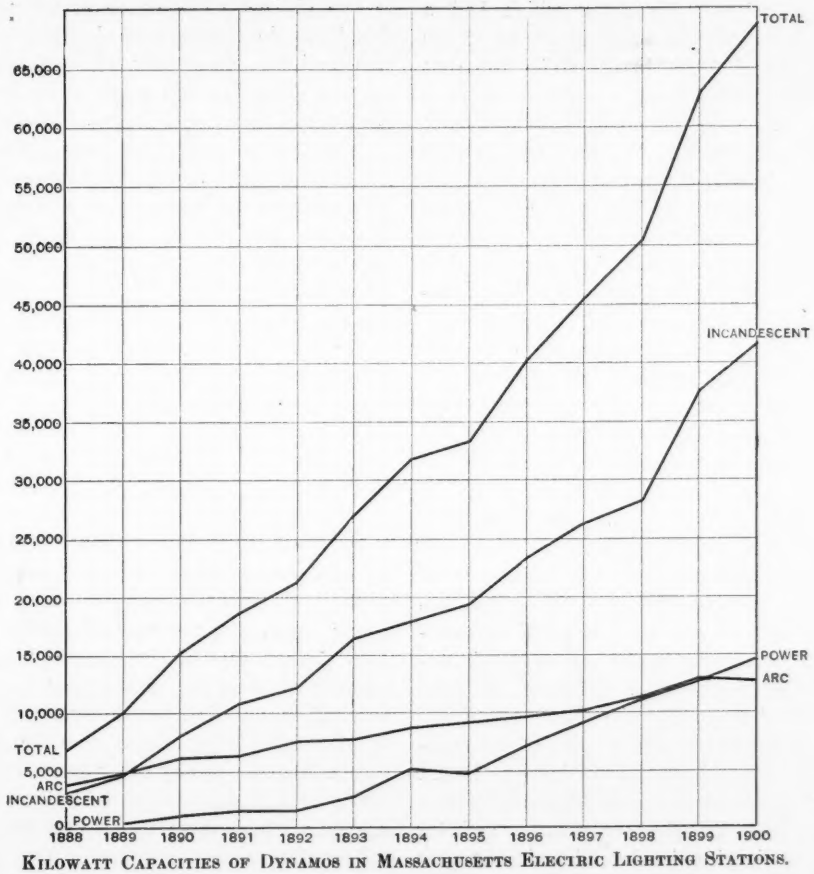
ELECTRICAL SUPPLY STATIONS IN MASSACHUSETTS.

BY ALTON D. ADAMS.

(*Copyright, 1901, by Alton D. Adams.*)

Arc lighting obtained the leading place in systems of public electrical supply while the problems of distribution for incandescent lamps were being solved. The brilliant rays from electric arcs struck popular fancy, and the lamps were rapidly adopted for street lighting and commercial purposes. For a time the milder light of the incandescent filament seemed of minor importance. During the first half of the decade from 1880 to 1890, the development of incandescent lighting in public systems was much hampered by the lack of means for cheap distribution over comparatively large areas. The expense of conductors on the two-wire multiple system, with 110-volt lamps became prohibitive at about one-fourth of a mile from the generating plant. The three-wire system multiplied the permissible radius of distribution by about three, but even this increase was too small to meet the scattered requirements for service in the majority of cases. Moreover, the claims of the Edison company to the exclusive use of the three-wire system were then generally respected. In some cases efforts were made to distribute incandescent lamps on series, series multiple and multiple series systems, but none of these attained satisfactory results, save to a limited extent for street lighting.

Contrasted with the limited-service area of early multiple systems for the distribution of incandescent lamps, arc lighting was necessarily done at high voltages, and miles of streets, or customers on opposite sides of a town, could be readily supplied with light from a single dynamo of less than 50-horse-power capacity. Under these conditions public electrical supply was initiated in Massachusetts, as in most other parts of the country, mainly with arc lighting.



KILOWATT CAPACITIES OF DYNAMOS IN MASSACHUSETTS ELECTRIC LIGHTING STATIONS.

The first important system of public electrical supply in the state seems to have been that of the Lowell Electric Light Corporation, which was chartered in 1881. Electric companies at Lawrence, Salem and Taunton followed in the year 1882, while in 1883 others were started at Brockton, Fall River and Worcester. During 1884 and 1885 the inauguration of electrical supply systems went on at about the same rate as in the two previous years, but in 1886 a marked increase took place in the rate of formation of new electrical companies, and continued through the remainder of the decade. Several of the earlier systems were designed for the distribution of incandescent lamps. As time went on, many companies that had started with only arc lamps, added incandescent dynamos to their equipment.

After the middle of the decade, from 1880 to 1890, the capacity of incandescent dynamos operated by electrical supply systems gained steadily on the capacity of arc machines. By July 1, 1888, the total capacity of incandescent dynamos in use by the central stations of the state had reached 3,047 kilowatts, while 3,795 kilowatts represented the similar capacity of arc machines, so that the former was 80 per cent of the latter. The capacities of all dynamos is here given in kilowatts for convenience in comparison, but in the early part of the period under discussion they were usually rated in arc or incandescent lamps. This early practice has long since given way to a kilowatt rating for incandescent dynamos, though the lamp rating still clings to the arc machines. As records of dynamos in the early stations give capacities in lamps it has been necessary to reduce these lamp ratings to kilowatts. This has been done by allowing 3.5 watts for each candle-power of lamp capacity in incandescent dynamos, and 0.25 watt for each candle-power of lamp capacity in arc dynamos. In the use of these figures, the candle-powers of lamps have been taken at the nominal ratings, such as 16 candles for incandescent lamps and 2,000 candles for arcs. The resulting watt capacities per lamp are: 16 candle-power, 56 watts; 1,200 candle-power, 300 watts; 2,000 candle-power, 500 watts, and capacities for other lamps in like proportion.

While the watt capacities assumed to correspond to lamp ratings may not be exact for some particular cases, especially for the early dynamos—which were often rated rather loosely—they appear to be sufficiently near the truth for practical purposes, and represent good practice at the present time.

Beginning with June 30, 1888, the accompanying tables show the capacities in kilowatts of arc and of incandescent dynamos in the electric lighting stations of private corporations of Massachusetts, also the per cent of increase in capacity for each class of machines during each year to 1900. Municipal electric stations are not included. From 1889, the actual capacity of electric power generators in the same stations, together with the yearly addition and the per cent of increase are given.

To further illustrate the capacities of the several classes of electrical machinery

in electric lighting stations, and the changes that have taken place, the four accompanying curves have been drawn. The curve marked "arc" indicates the capacity in kilowatts of all the arc machines in the stations of the state, on June 30 of each year, from 1888 to 1900. Similar facts as to incandescent dynamos are shown by the curve marked "incandescent." The capacity of power generators, or dynamos used to supply either stationary or street-car motors, is shown for each year by the curve marked "power." The tables also show the combined capacity of the three classes of electrical machinery for each year, together with the addition yearly made and the percentage of increase. A fourth curve, marked "total," also shows the total capacity of all classes of dynamos in the electric lighting stations of Massachusetts, for each year from 1888 to 1900.

The capacity of arc dynamos had probably passed its greatest rate of increase before it reached the total of 3,795 kilowatts on June 30, 1888. Taking the table and the curve for arc dynamos, it appears that the greatest rate of increase in capacity during the period covered by the present figures occurred in the year from June 30, 1888, to June 30, 1889, when it was 27 per cent, and a capacity of 1,068 kilowatts was added. Shortly after the middle of 1889, arc dynamos lost their position of supremacy as to capacity, as is shown by the crossing with the incandescent curve. Probably few, if any, noted this change at the time, but the forces that led to it have proved to be of vast importance in the electrical field. Though the arc system was no longer king, the capacity of its dynamos increased 25 per cent during the year of 1889 and 1890. For the year of 1890 and 1891 the rate of increase fell to 3.4 per cent, only 209 kilowatts capacity being added. The next year saw an increase of 19 per cent, a rate that has not since been equaled. From the middle of 1897 the capacity of arc dynamos started on another and probably its last rapid upward movement. During 1897 and 1898 a capacity of 1,024 kilowatts, and in 1898 and 1899 1,666 kilowatts was added to the arc dynamos in Massachusetts stations. By the middle of 1899 the arc capacity reached a total of 12,866 kilowatts, which seems likely to remain the highest point in its history. As shown by the curve, the following year witnessed a decrease for the first time in the capacity of arc machines amounting to 1.5 per cent. In this same year the arc curve is again crossed in its course, this time by the power curve. Thus during 12 years the capacity of arc dynamos has been exceeded by both incandescent and power machines.

At the beginning of the period the incandescent dynamos were inferior competitors of the arc, and the operation of power generators had little more than begun. The actual decline in the capacity of arc dynamos during the last year of the period is probably due, in large part, to the increasing use of enclosed arc lamps on circuits from alternating incandescent dynamos.

Arc dynamos end the period with a total capacity of 12,673 kilowatts, or 334 per cent of that with which they begun it.

Incandescent dynamos, which had a total capacity of 3,047 kilowatts at the middle of 1888, increased 55 per cent during the following year, and at its close the capacities of arc and incandescent machines were for the first and last time about equal. Seventy per cent was added to the capacity of incandescent dynamos in the year of 1889 and 1890, a rate of increase that has not since been equaled.

The growth of capacity for these dynamos has continued at varying rates throughout the entire period to 1900, as shown by the constantly rising curve. By far the largest expansion in a single year was that of 1898 and 1899, when 9,410 kilowatts were added to the capacity of incandescent machines, representing an increase of 33 per cent. The introduction of the alternating system, with its large radius of economical distribution, is no doubt the largest single factor that has operated to produce this rapid and continued increase in the capacity of incandescent equipments. Through a large part of the period the alternating dynamos simply supplied a share of the growing demand for incandescent lamps. Later, an increasing part of arc lamp service, both to private consumers and for street lighting, has been done by the same alternating dynamos that supply incandescent lamps.

Stationary motors have proved to be a load of increasing importance on incandescent dynamos. This load, at the beginning of the period here considered, was confined to direct-current systems, but alternating machines have begun to supply a few of the motors during its latter part, and their share of this service is increasing. By the middle of 1900, the total capacity of incandescent dynamos, or those delivering energy at a practically constant pressure suitable for distribution to incandescent lamps, directly or through transformers, had reached 41,713 kilowatts. As the capacity of these dynamos was only 3,047 in 1888, the 12 years show an increase of 1,369 per cent. This figure is a striking illustration of the growth of the electrical industry and the popularity of the incandescent lamp.

In 1888 electric power generators, or, as they were then called, motor-generators, that is, dynamos especially intended to supply energy for electric motors, had been installed in lighting stations to only a very slight extent. By the middle of 1889 the capacity of the power generators in Massachusetts stations had only reached the comparatively trifling figure of 483 kilowatts.

This class of dynamos was early devoted to two distinct purposes, as at present; that is, to the operation of electric street cars and to the supply of stationary motors. This fact has much to do with the form of the "power" curve. As street railways adopted electrical equipments, the existing lighting stations were called on to operate the necessary generators in numerous cases. When the success of the electric street cars was assured, some of the generators were moved from the lighting stations to independent power-houses. These removals operated, to a large extent, to keep down the capacity of power dynamos at lighting stations.

On June 30, 1894, the capacity of power generators in lighting stations had reached 5,165 kilowatts, but it declined by 392 kilowatts during the following year. From the middle of 1895 the capacity of these generators increased steadily to the end of the period, as shown by the power curve. In the year of 1893 and 1894 the per cent of the increase in the capacity of these generators was 92, and the rating added 2,482 kilowatts, this latter number being greater than the corresponding one in any other year of the series. From the middle of 1894 to the middle of 1895 there was a decrease of 8.2 per cent in the capacity of power generators in electric lighting stations, due to the removal from them of some generators that supplied power to street railways.

On June 30, 1900, the capacity of these generators was 14,555 kilowatts, an increase of 3,134 per cent over the capacity at the middle of 1889. This multiplication by more than 31 of the capacities of electric power generators does not include the large number of these machines in the street railway power-houses of the state.

By July 1, 1888, the combined capacity of arc and incandescent dynamos in lighting stations had reached 6,842 kilowatts.

Before the close of the following year power generators for street car and stationary motors began to swell the total capacity. As may be noted from the curve marked "total," the united ratings of all three classes of dynamos have, with one exception, added a large increment of capacity every year. The period from the middle of 1894 to the middle of 1895 shows the smallest gain of any year of the series, the increase of capacity having been only 1,507 kilowatts, and the per cent 4.7. The largest relative gains were made in the two years from June 30, 1888, to the like date for 1890, the initial capacity having been quadrupled during this period. In 1894 and 1895 the small rise of the curve is no doubt due to the prevailing industrial depression that followed the panic of 1893, and to the removal of some street railway generators from electric lighting stations to independent power-houses.

About twice the dynamo capacity gained in any other year was added to the lighting stations from the middle of 1898 to the middle of 1899, the increase amounting to 12,530 kilowatts. On June 30, 1900, the combined capacity of dynamos in the electric lighting stations of the state had reached a total of 68,941 kilowatts, an increase of 1,007 per cent during 12 years. Looking back over this period it is seen that the initial capacity of arc dynamos has been multiplied 3.34 times, that of incandescent dynamos 13.69 times, the capacity of power generators since the middle of 1889 has increased 31.34 times, and the total rating of dynamos of all classes in the lighting stations of the state 10.07 times. Of the combined capacity at the middle of 1900, the arc dynamos represented 18.2 per cent, the power generators 21.1 per cent, and the incandescent dynamos 60.5 per cent. In contrast with these figures, the arc dynamos at the middle of 1888 had 55.4, and the incandescent dynamos 44.5 per cent of the total capacity.

The chief interest of these figures is not to represent the capacity of dynamos in Massachusetts so much as to illustrate the growth of electrical distribution, of which the results recorded for this state are simply an example.

Rapid as has been the increase, and great as is the present capacity of dynamos in public stations, the figures are quite inadequate to represent the addition made by the electrical arts to the comforts and enjoyments of civilized life.

Capacity of arc dynamos in electric lighting stations of Massachusetts:

Year Ending June 30.	Total Kilowatts.	Kilowatts Added During Previous Year.	Per Cent of Increase.
1888	3,795		
1889	4,863	1,068	27.0
1890	6,118	1,255	25.0
1891	6,327	209	3.4
1892	7,536	1,209	19.0
1893	7,823	287	3.8
1894	8,705	882	11.0
1895	9,111	406	4.6
1896	9,613	502	5.5
1897	10,176	563	5.8
1898	11,200	1,024	10.0
1899	12,866	1,666	14.0
1900	12,673	193 decrease	1.5 decrease

Capacity of incandescent dynamos in electric lighting stations of Massachusetts:

Year Ending June 30.	Total Kilowatts.	Kilowatts Added During Previous Year.	Per Cent of Increase.
1888	3,047		
1889	4,728	1,681	55.1
1890	8,057	3,328	70.4
1891	10,796	2,739	33.9
1892	12,180	1,384	12.8
1893	16,447	4,267	35.0
1894	17,879	1,432	8.7
1895	19,372	1,493	8.3
1896	23,448	4,076	21.0
1897	26,249	2,801	11.0
1898	28,156	1,907	7.2
1899	37,566	9,410	33.0
1900	41,713	4,147	11.0

Capacity of electric power generators in lighting stations of Massachusetts:

Year Ending June 30.	Total Kilowatts.	Kilowatts Added During Previous Year.	Per Cent of Increase.
1889	483		
1890	1,069	586	121.0
1891	1,470	401	37.0
1892	1,472	2	
1893	2,683	1,211	82.0
1894	5,165	2,482	92.0
1895	4,773	392 decrease	8.2 decrease
1896	7,165	2,392	50.0
1897	9,036	1,871	26.0
1898	11,134	2,098	23.0
1899	12,588	1,454	13.0
1900	14,555	11,967	15.0

Capacities of all dynamos in electric lighting stations of Massachusetts:

Year Ending June 30.	Total Kilowatts.	Kilowatts Added During Previous Year.	Per Cent of Increase.
1888	6,842		
1889	10,074	3,232	47.0
1890	15,244	5,170	51.0
1891	18,593	3,348	21.0
1892	21,188	2,596	13.0
1893	26,953	5,765	27.0
1894	31,749	4,796	17.0
1895	33,256	1,507	4.7
1896	40,226	6,970	20.0
1897	45,461	5,235	13.0
1898	50,490	5,029	11.0
1899	63,020	12,530	24.0
1900	68,941	5,921	9.3

Two Pennsylvania machinists, Thomas Smith, of Pittsburgh, and Frank G. Sherry, of Wilkesburg, have secured patents on a process whereby steel and copper sheets can be rolled and welded together securely without the use of rivets. It is said that a large steel company has made an offer for the process.

Another Wireless Telegraph System.

At Vesinet, France, Colonel Pilsoudski, an engineer in the Russian Army, and M. Victor Popp, a French electrical engineer, have been making some experiments with a new system of wireless telegraphy, which they claim is an improvement on that of Signor Marconi. The new system is claimed to be more simple in that no tall masts are required and the electric waves follow the earth's surface. The apparatus consists of two electrodes separated by a distance which varies according to the distance of the place with which it is desired to communicate. The negative is placed on a sheet of glass and the positive is buried in the earth to a depth of from three and one-half to four metres. The two electrodes are connected to the transmitting apparatus, and the same arrangement is installed at the receiving station. The inventors claim that under the new system wireless telegraphy with America will be possible.

The Telegraph in the Philippines.

Construction of telegraph lines in the Philippine Islands is becoming quite a feature of the development of this part of the United States's new possessions. Prior to the fall of Manila the Spaniards only used the telegraph in the vicinity of that city. Now there are hundreds of miles of wires in every part of the island which has been occupied by American troops. There are nearly 1,000 telegraph offices in the archipelago, and every week new ones are being added. The Filipinos, who were at first hostile to the telegraph lines, have now become reconciled to the innovation, and the authorities are having less trouble on account of their depredations. While the lines have been constructed for the use of the military service, at the same time the native business establishments are beginning to use them, the government making a fair charge for such use. Recently some of the mining concerns and plantation proprietors have combined to construct a line for their own private use.

A Yukon Telegraph System.

The Canadian Government is building a telegraph line, which will soon be completed, from Portland Canal, which separates British Columbia from Alaska, to Hazelton, 180 miles distant, where it joins the line from Dawson to Ashcroft. With the completion of a small gap in the latter line, a system of 1,843 miles will be in operation. The revenue from that part of the system completed up to December 31, 1900, amounted to $107,712, and the total number of messages which had been sent was 41,816. The cost of the entire line will be about $460,000.

RADIO-ACTIVE SUBSTANCES AND THEIR RADIATIONS.*

BY GEORGE B. PEGRAM.

During the past five years many physicists, attracted by the freshness of the field and the promise of important discoveries, have turned their attention to the study of the newly discovered radio-active substances. The result has been a rapid increase in knowledge of and interest in the phenomena, until now the main facts are known to all scientists, but, since the knowledge of the subject is increasing so fast, a short review is now and then acceptable and necessary, especially to those whose chief interests lie along other lines. In this article an attempt is made to point out the more interesting features of the subject.

The real discovery of the persistent radiations from the uranium compounds was made by M. Henri Becquerel in 1896. It had been stated by M. Niewenglowski that under the action of sunlight certain phosphorescent salts emit radiations which can penetrate black paper. In testing whether this applies to uranium salts, M. Becquerel discovered to his surprise that with uranium salts exposure to sunlight is unnecessary; uranium compounds are all the time giving off radiations which can pass through opaque bodies and affect a photographic plate on the other side. It was soon found that the uranium radiations discharge electrified bodies in the neighborhood by ionizing the surrounding air after the manner of cathode and X-rays. Naturally, about the first hypothesis was that the radiations are ether vibrations, perhaps of very short wave-length, and many attempts were made to find evidence of reflection, refraction or polarization, with the result that none of these properties nor any of the properties peculiar to wave motion has yet been shown to belong to these radiations.

A few months after the discovery of the uranium radiations Professor Schmidt and Mme. Curie, a Polish physicist working in Paris, independently discovered the radio-activity of thorium compounds. An elaborate study of thorium radiations has since been made at McGill University by Professors Rutherford and Owens.

A greater discovery, however, was in store for Mme. Curie; for observing that many specimens of pitchblende, the principal ore of uranium, were more strongly radio-active than the pure uranium salts, she and her husband attempted a chemical separation of the suspected more active element. The result is well known; they succeeded in isolating two substances having at least 100,000 times the radio-activity of uranium. The first of these substances, which they named polonium, follows the bismuth in the separation from pitchblende. The separation from the bismuth is effected by taking advantage of the fact that polonium sulphide is more volatile than bismuth sulphide. The second substance they named radium. It follows barium in its chemical reactions, but its chloride is less soluble in water than barium chloride, which affords a means of separation from the barium. Another very active substance has been obtained form pitchblende by M. Debierne. He has named it actinium. Chemically it is closely allied to titanium.

No one of these three substances has been obtained free from impurity, and the amounts obtained are exceedingly small, only a few centigrammes from a thousand kilogrammes of pitchblende.

The spectrum of radium has been carefully examined by M. Demarcay, who assigns to it several new lines, the strongest having wave-lengths 4,683 and 3,814.7, and two bands. No characteristic spectrum has yet been found for polonium or actinium. On account of the small quantities of these substances available, no accurate atomic weight determinations have yet been made, but from what has been done it appears that radium has a higher atomic weight than barium.

At first it was supposed that the uranium itself was the source of the radio-activity of the uranium salts, since often the activity of the compounds seemed to depend on the amount of uranium present, but after the discovery of radium and polonium the radio-active power of uranium began to come under suspicion. Professor Crookes found that often different specimens of the same uranium salt would have very different radio-active strength, which difference in strength could be very little changed by changes in chemical or physical conditions, the strongly active salt remaining so and the less active salt never gaining strength. Suspecting that the radio-activity was due to something other than the uranium, Professor Crookes set about separating this irrepressible element. Such was his success that, starting with active uranium nitrate, he was able to obtain from it uranium nitrate which had no effect on a photographic plate even with an exposure of seven days. At the other end of the separation he had a substance many times as active as the original salt. The best and simplest of several methods of separation makes use of ether as a solvent. The ether dissolves the uranium nitrate and leaves undissolved most of the radio-active substance. This substance Professor Crookes calls UrX, the X testifying to our present ignorance of its real nature. Professor Crookes has also tried to separate the active material from the thorium compounds, but has so far met with only partial success. It seems not unlikely, though, that it may yet be done as completely as in the case of uranium. Meanwhile it is convenient still to speak of uranium and thorium radiations.

PHOTOGRAPHIC AND CHEMICAL EFFECTS OF THE RADIATIONS.

The photographic effect was the one first discovered and it remains the most delicate test for radio-activity, for the effect is cumulative, and the exposure may be made as long as desired. Any one can obtain very good radiographs from any of the ordinary uranium salts by using rapid dry-plates and an exposure of two days, while visible effects can be obtained with a much shorter exposure. Polonium and radium affect a photographic plate in a few minutes if sufficiently close to it. Even with a distance of a meter between the radium and the plate, radiographs have been obtained after a few days' exposure. These are very sharp, showing thus the rectilinear propagation of the radiations. Polonium radiations are so rapidly absorbed by the air that no effect is produced with a greater distance than a few centimetres.

Under the action of the radium radiations glass takes a permanent brown or violet tint. The haloid salts of the alkali metals become colored just as under the action of the X-rays. Paper is sometimes discolored and under certain conditions ozone may be formed in the neighborhood of the very active substances. Barium platino-cyanide is colored brown.

The action of the radium rays on the skin is the same as that of the X-rays. At first there is a slight reddening of the skin, but after three or four weeks' exposure severe inflammation sets in.

FLUORESCENCE.

Most of the substances that show fluorescence under the action of ultra-violet light or the X-rays also fluoresce under the action of the radium radiations, while those that fluoresce under ordinary light do not fluoresce under the radium radiations; but there are numerous exceptions to these rules.

*From *Science*.

It is a very interesting fact that when freshly prepared the radium salts are faintly self-luminous, and this property seems to be retained as long as the salt does not absorb moisture. It is this property that has excited much of the popular interests in the radium salts, for it is a case of the longed-for light without heat. In fact, it is light with no apparent source of energy whatever. If radium chloride ever becomes cheap we may be given an opportunity to court fortune by investing in preferred stock of some "International Radium Illuminating Company." Just at present gold is dirt cheap in comparison with these radium salts. The self-luminescence is due to the fact that under the action of its own rays either the salt itself, or some of the unavoidable impurities, fluoresces.

Some of the tissues of the eye fluoresce under the radium rays, so a sensation of light is felt when some of the salt is brought before the closed eyelids or placed on the temple.

IONIZATION OF GASES.

Any gas traversed by the Becquerel rays, as Mme. Curie has named the new radiations, is made capable of conducting electricity. This conductivity is of the same nature as that produced in gases by the cathode and X-rays. According to the accepted hypothesis, the positive and negative particles or ions of the gas are knocked apart by the radiations, and the motion of these free-charged ions, when directed by an electric field, constitutes the electric current. If an ionized gas is left to itself the positive and negative particles soon reunite and, in fact, the reuniting process goes on all the time in proportion to the number of free ions in the gas, so that under any given intensity of ionizing radiation a condition of equilibrium is soon reached in which the reuniting goes on as fast as the ionizing. Since the amount of ionization may be measured by measuring the electrical conductivity of the gas, this affords a convenient means of comparing the relative strengths of radio-active substances, and one which is much more rapid and accurate than the photographic one. It is by no means certain, however, that the radiations most effective for ionization will therefore produce most effect on a photographic plate. Ionization is proportional to the absorption of the radiations by the gas, so that if a bit of radio-active substance be placed between two metal plates a greater current may be sent between them when they are two centimetres apart than when they are only one, the greater thickness of the air in the first case absorbing more of the radiations.

An ionized gas is in many respects similar to an ordinary liquid electrolyte, and Lord Kelvin has shown that when a plate of copper and a plate of zinc are connected by a wire and the air between the plates exposed to radiations from uranium compounds, a current flows through the connecting wire just as if the plates were immersed in a liquid electrolyte. It has recently been shown that the Becquerel rays decrease the resistance of selenium just as light and the X-rays do.

PENETRATING POWER.

The radiations from the various substances are not at all homogeneous, some being very penetrative, others being easily stopped by any substance. Polonium radiations, while intense, are of the non-penetrating kind, being stopped by even the thinnest metal foil. Uranium radiations, and therefore Crookes's U*r*X radiations, are much more penetrating, passing through metals, glass, and in fact all substances, but with considerable loss of intensity. Thorium compounds emit radiations of at least two very different penetrating powers, one part only feebly penetrating, another as penetrating as the U*r*X radiations. Radium and actinium also emit both penetrating and non-penetrating rays, some of the radium rays being the most penetrating of all. Screens of sheet metal act as sieves for the rays, soon cutting off the less penetrating rays and allowing the more penetrating kind to go through with but little diminution in intensity. One sheet of tin, 0.0025 mm. thick, transmitted 44 per cent of the radiations from one radium specimen, two sheets of the same thickness transmitted 31 per cent, and 15 sheets 15 per cent. A sheet of glass, 0.16 mm. thick, transmitted 26 per cent, and 10 plates 16 per cent. Aluminum, 0.16 mm. thick, transmitted 28 per cent, six sheets 16 per cent. On account of the non-homogeneity of the radiations it has been very difficult to determine the law of absorption, but it appears that for the rays of the most penetrating type, at least, the absorption is proportional only to the density and thickness of the absorbing screen, the kind of material, whether platinum, paper, glass, air or other substance, making but little difference. Because some of the less penetrating rays are absorbed by the salt itself, there is a larger proportion of the very penetrating rays in the radiations from a thick layer of the salt than in those from a thin layer.

DEFLECTION IN A MAGNETIC FIELD.

Several experimenters discovered about the same time that some of the Becquerel rays are affected by a magnetic field. This brought out strongly their resemblance to the cathode rays, and further experimenting proved that if a beam of radium radiations is made to pass through a magnetic field which is perpendicular to the direction of the beam, then the beam is deflected just as a beam of cathode rays would be, that is, just as a stream of negatively charged atomic projectiles would be deflected. This fact furnished the basis for the present accepted hypothesis, namely, that the deviable rays consist of a stream of rapidly moving particles charged with negative electricity. The deflection in a magetic field gives further proof of the non-homogeneity of the radiations. The experiment is as follows: A vertical beam is obtained by placing the radio-active salt at the bottom of a narrow hole in a block of lead, which is then placed on a horizontal photographic dry-plate or a fluorescent screen in the horizontal field of a large electromagnet. When the magnet is energized the vertical beam of rays is deflected in a direction always perpendicular to its direction of propagation, and also perpendicular to the magnetic lines of force, so that it is finally bent over until it falls upon the plate or screen. The impression produced is not a spot, but a band or magnetic spectrum, which could not be the case if the beam were composed of homogeneous radiations. According to the electrified-projectile hypothesis this can be explained by saying that the particles do not all have the same velocity, in which case those having the highest velocity would be the least deflected. This view has support in the fact that of the deviable rays the least deviable are the most penetrating, as we should expect from the higher velocity of the particles. Becquerel found that for the rays from a sample of radium the product of the strength of the field into the radius of curvature of the path varied from 350 to 3,000.

There are, however, certain rays that are not deflectable in a magnetic field, and these are of the least penetrating kind, which, according to the charged-particle hypothesis, should, on the contrary, be most deflected by the field. A satisfactory hypothesis as to the nature of these non-deflectable, non-penetrating radiations has not yet been put forth. Perhaps they consist of particles of much larger mass than those of the deflectable rays. M. Villard finds also in the radium radiations a small proportion of very pene-

trating, non-deflectable rays, quite similar to the X-rays.

ELECTROSTATIC EFFECTS.

Now a stream of charged particles deflectable by a magnetic field should also be deflected by an electrostatic field. This is found to be the case. Furthermore, a shower of negatively charged particles ought to impart a negative charge to an insulated conductor. Of course, in this case air would not act as an insulator, for it becomes a conductor under the action of the rays. M. and Mme. Curie got around this difficulty by insulating a conductor with a thin layer of wax over its surface, then exposed it to radium radiations and found that it became highly charged negatively. Insulating some of the radium salt in the same manner with wax, they found that it became highly charged positively, a beautiful corroboration of the theory that there is a separation of the atomic particles with their charges. If, as now seems almost certain, the negatively charged part of the atom has a mass only a small fraction, a thousandth, perhaps, of that of the positive part, it is very reasonable that the negative particles would be the ones to be shot out in case of interatomic commotions. The rate of charging in the experiment was about 4×10^{-12} amperes per square centimetre of the radium salt.

VELOCITY, MASS AND ENERGY OF THE RADIATIONS.

The velocity of a charged particle and the ratio of the charge to the mass may be found by comparing its path in a magnetic field with its path in an electrostatic field. Then assuming the charged particle hypothesis, it should be possible to calculate the velocity of the particles in the deflectable rays from the radio-active substances. This has been done by M. Becquerel. The curvature of the path in the magnetic field can be measured without much difficulty, but the deflection in the electrostatic field is very small. The difficulty of the experiment is also increased by the complex character of the radiations, making it uncertain if rays of just the same kind are being observed in the two fields. Some confidence, however, must be placed in the results, though they give for the velocity of the particles an astounding figure, about half the velocity of light. How from a quiet, peaceful bit of white salt particles can be shot off with such a velocity as this remains for explanation. The ratio of the charge to the mass of the particles is of the same order as in the case of the cathode rays, another evidence that the atomic charges are invariable and inseparably connected with the particles.

By measuring the rate at which a charge is imparted to a conductor, and then using the values of the velocity and of the ratio of the charge to the mass determined as above, the kinetic energy per second of the particles emitted may be calculated. For a square centimetre surface of a very active radium preparation it has been found to be 5.1 ergs per second, or five-ten-millionths of a watt. The mass of the particles, calculated from the same data, is exceedingly small, the loss from a square centimetre of surface being something like a milligramme in a thousand million years. M. Becquerel observes that it is of the same order as the evaporation of certain odorous bodies.

Professor Rutherford and Mr. McClung made last year some interesting experiments on the energy required to produce ionization of gases by cathode and X-rays. Assuming that the same energy is required to produce ionization by the Becquerel rays, they estimate that a square centimetre surface of a thick layer of uranium oxide gives off energy at a rate not less than 10^{-11} calorie per second, which is sufficient to raise the temperature of one gramme of water one degree centigrade in 3,000 years. In the case of radium, 100,000 times as active as uranium oxide, the energy given off is not less than 3,000 calories per year for a gramme of substance. The value for the energy is 40 or 50 times as large as the value mentioned above, obtained by the other method. That the amount of energy concerned is so small emphasizes the extreme delicacy of the photographic and ionization tests.

SECONDARY RADIATIONS.

X-rays impinging on some substances induce secondary radiations, and it was soon found that the Becquerel rays also possess this power, with the important difference that the secondary radiations induced by the Becquerel rays continue after the action of the primary rays has ceased, which is not the case with those induced by the X-rays. These secondary radiations affect photographic plates and ionize gases. The radium preparations are the most active in producing secondary radiations, and the effect is produced equally well in the case of such different substances as platinum, zinc, bismuth and even paper. Up to a certain limit the intensity of the secondary rays increases with the time of exposure to the radium; after the removal of the radium the intensity gradually weakens, disappearing altogether after some hours. The source of the secondary rays was thought to be a fine dust which escapes from the radium and settles on neighboring bodies, but it can not be removed by washing, and the radium rays have the power of imparting it even after passing through metal screens. It seems, too, that this power of emitting radiations may even be imparted to gases. A number of substances may be made strongly radio-active by precipitation from solutions containing small amounts of the most active substances, and several times these temporarily active substances have been mistaken for compounds of new elements. It is not yet known to what extent the secondary radiations are like the primary, for their intensity is so small that a comparison is difficult.

Thorium oxide gives off a remarkable vapor or "emanation" which causes a strong secondary radio-activity. This emanation can pass through paper and even very thin metal. It gradually diffuses itself throughout the air and is carried about by air currents. Air containing the emanation retains its electrical conductivity for as long as 10 minutes after the thorium oxide is removed, though ordinary ionized air loses its conductivity in a few seconds. The emanation is not removed from the air by drawing it through wool or bubbling it through water or sulphuric acid. Any substance charged with negative electricity collects and concentrates the emanation, becoming very radio-active after a few hours in the presence of thorium oxide. Sandpapering or treatment with sulphuric acid removes the emanation from a platinum wire on which it has been concentrated. On afterward evaporating the acid a radio-active residue may be obtained. The thorium emanation much resembles a fine radio-active dust.

NATURE OF THE RADIATIONS AND SOURCE OF THEIR ENERGY.

We may say then that for one component of these complex radiations a satisfactory explanation is offered. This component is of the same nature as the cathode rays, and consists of a rapidly moving stream of minute material particles, each having its charge of negative electricity. Another component is similar to the X-rays, and is probably a phenomenon of the ether rather than of ordinary matter. Perhaps this component is produced by the action of the first component, as the X-rays are produced by the action of the cathode rays. For the rest no satisfactory explanation has been given. Many of the secondary effects seem to result from a fine dust emitted from the radio-active

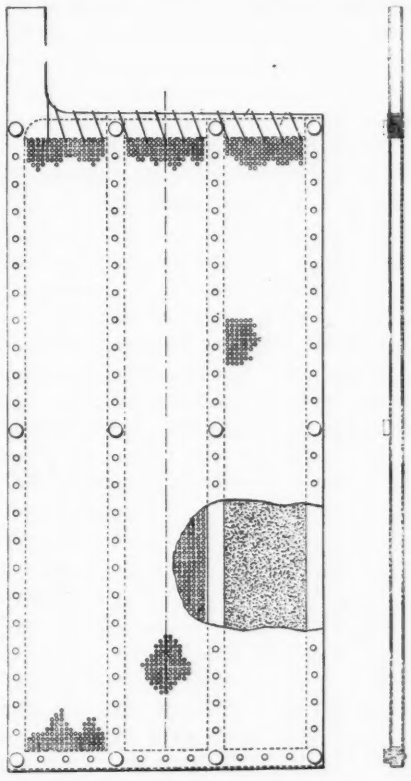
substance. Possibly there is only a single primary radiation, the rest being secondary effects, as the cathode rays generate the X-rays and these in turn generate their complex secondary radiations.

The chemical nature of the radio-active substances or elements is still little understood, nor is it surprising when one considers the difficulty of working with substances occurring in such minute quantities as these. Only one new element, radium, is definitely established. Hofmann and Strauss thought they had isolated another new radio-active element, but while still claiming the new element, they now admit that it is not radio-active.

The question of the source of energy in these radiations is yet unanswered. Is the energy potential in an unstable molecular or atomic structure, or is it supplied continuously by outside sources? In the first case, how long will the energy last? In either case, is it a property that matter in general may under proper conditions assume, or is it, as it seems, restricted to a very few peculiar elements? Heat or cold, high or low pressure, has little influence on the emission of the rays. Mme. Curie once put forth the hypothesis that perhaps the radiation is induced in the radio-active elements by a sort of transcendental radiation more penetrating than the X-rays and pervading all our space. Professor Geitel found that if so, the exciting radiations penetrate easily hundreds of yards of rock, for radium was still active at the bottom of the deepest mine to which he had access. Finally, the study of the radio-active substances will surely lead to a better knowledge of that which is the subject of much of the physical research of to-day, the intimate structure of matter.

Electrical Patents

For some time Mr. Edison has been working to improve galvanic or storage batteries, with a view to increasing the permanency of the same while decreasing the weight. To this end he devised a cell wherein the metals, cadmium and copper, are employed as the elements in an alkaline electrolyte, whereby a very permanent cell was secured, having the initial and final states of the electrolyte the same. Furthermore, it was capable of storing a greater amount of energy per pound per cell than batteries commercially used before that time for the same degree of durability. Not satisfied with this, however, he has been seeking, by a great many experiments, for an element or compound capable of being used in an alkaline electrolyte, the heat of formation of whose oxide should be as low or lower than that of oxide of mercury. In this he has been successful, the result being the discovery of an element for furnishing the oxygen to the oxidizable element on discharge with even greater freedom than oxide of mercury. At the same time, the new element is less expensive, is of less weight, but greater permanency and greater insolubility in the electrolyte. He has been granted a broad patent on his new element, and the following extract from his patent specification clearly describes the method of manufacturing the same:



EDISON'S STORAGE BATTERY PLATE.

"In the manufacture of my new oxidizable element for use in a reversible galvanic cell I first preferably take monosulphide of iron and reduce it by a crushing operation until the particles thereof may be passed through a screen having about 40,000 openings per square inch, and I intimately mix about eight parts, by weight, of the powdered monosulphide with about two parts, by weight, of flake graphite of a size considerably larger than the perforations in the walls of the pockets or receptacles. Flake graphite being exceedingly thin and of large area gives an extensive conducting surface in proportion to its bulk and weight. This mixture is then moistened with a 20 per cent solution of potassic hydroxide, and the dampened mass is packed into the pockets or receptacles of the proper plates by a suitable tamping tool. Owing to the want of flexibility of the graphite, the mixture packs to a hard, porous mass. The effect of electrolytic gasing, therefore, does not disintegrate the mass as a whole when properly compressed. After each pocket or receptacle has been tightly packed with the mass almost to its top, a wad of asbestos fibre about a quarter of an inch in thickness is introduced into the pocket or receptacle above the mass, and on top of this packing is placed a strip of sheet nickel entirely covering the asbestos and filling the mouth of the pocket, which strip is permanently secured in position by nickel wires threaded through the openings near the top of the pocket, as shown in the illustration. The element thus formed is subjected to electrolytic oxidization in a solution of potassic hydroxide, whereby sulphur will be set free and combining with the alkali forms a sulphide of potassium, which diffuses out of the mass, while the iron is converted to a ferrous oxide thereof. This diffusion of the alkaline sulphide out of the plate is hastened and facilitated by subjecting the contents of the plate to alternate oxidation and reduction by alternately reversing the oxidizing current, and by several of these operations the whole of the sulphur will be eliminated and the element will be ready for use after the iron has been reduced to the metallic state. Since iron does not decompose water, there will obviously be no local action between it and the graphite. The oxide formed from the sulphide increases in bulk and being intermediately mixed with the graphite produces considerable pressure on the walls of the plate, which prevents any disturbance of the initial state of the mass, even when it is subjected to strong gasing within the pores by overcharging the element electrically. The object of using the monosulphide is to secure the greatest amount of iron oxide in the smallest space and in a form capable of being reduced to the metallic state electrolytically. My attempts to utilize iron as the oxidizable element in an alkaline reversible battery were for a long time frustrated by the facts, determined only after exhaustive experiments, that dried oxides of iron were not reducible to any extent by the current; that spongy iron reduced by hydrogen from different iron salts was not oxidizable to any considerable extent by the current; that the hydrates of iron were very bulky and difficult of use without drying, which operation effected some obscure change therein to render them nearly inert in the presence of the reducing current; that

bulky ferric oxide was not capable of any considerable reduction by the current, and, finally, that ferrous oxide, though easily reducible, was very difficult to prepare on account of atmospheric oxidation. The formation of the ferrous oxide, in the first instance, within the pockets or receptacles did away with the objections due to the bulk of the hydrates, while the oxide thus formed is perfectly reducible by the current. Instead of forming the oxide in this way by oxidizing the monosulphide in an alkaline solution, it will be obvious that salts of iron, like ferrous chloride, may be packed with the graphite and when placed in an alkaline solution form chloride of the alkali and ferrous oxide of iron, the alkaline chloride diffusing out of the mass. The results, however, are not so good as when the sulphide of iron is used, since the quantity of finely divided iron produced thereby is considerably less and is also less porous, offering, therefore, a reduced opportunity for the solution to penetrate the mass and lowering, in consequence, its current-conducting capacity. Metallic iron, even, when finely divided, as produced by electrolytic reduction, does not of itself oxidize in solutions of the fixed alkalies, and the oxide of iron is not appreciably soluble. Compact, dense or non-porous iron—*i. e.*, iron having relatively large particles—when subjected to a powerful electrolytic oxidation forms a small quantity of a soluble ferrate of the alkali and dissolves in the electrolyte. On the other hand, finely divided iron obtained as described when subjected to electrolytic oxidation does not form a soluble ferrate, but is converted into the insoluble ferrous oxide. My improved oxidizable element is, therefore, absolutely permanent, so that in the operation of the battery the electrolyte is not changed at any stage of the working, and absolutely no deterioration of the iron element takes place. Having described the advantages and characteristics of and the preferred manner of making the oxidizable element, reference will now be made to the preferred oxygen furnishing or storing element of the cell. I have discovered by experiment that the lower oxides of nickel and cobalt when in contact with a conductor in an alkaline solution can be almost wholly raised from this lower to a higher stage of oxidation electrolytically than is possible by chemical means and that these higher oxides revert to a lower stage by reduction with extreme ease, and availing myself of this fact I have constructed an oxygen-storing element capable of great capacity, of light weight and of high permanence. Neither the oxide of nickel nor of cobalt is appreciably soluble in an alkaline electrolyte, and both nickel and cobalt give nearly the same voltage in use; but since nickel is less expensive than cobalt I prefer to use the former element for the purpose. The preferred process for making the oxygen-storing element consists in first precipitating either the monoxide or black hydrated dioxide of the metal—say nickel—in the usual way, washing the precipitate free from the products of the reaction, filtering off the liquid and drying off the precipitate. The resulting dried hydrated oxide is then powdered very fine and is ready for use. Either oxide may be used with the same results. The process above outlined applies to cobalt as well as to nickel. About seven parts, by weight, of the finely powdered hydrate and three parts, by weight, of flake graphite are then intimately mixed and moistened with a small quantity of a strong solution of potassic hydroxide, so as to dampen the mass, which is then inserted in the pockets or receptacles of the proper plates in small quantities at a time and thoroughly tamped at each accession. Finally the mass is covered with a layer of asbestos, held in place by a plate of nickel secured in position by nickel wires, as I have described in explaining the make-up of the oxidizable element. The plates, the pockets of which are thus supplied with the mixture of the hydrated oxide and graphite, are then immersed in a solution of potassic hydroxide in water and subjected for a considerable time to an oxidizing current of about 50 milliamperes per square inch of surface, during which the oxide is either raised to a higher stage of oxidation than the black oxide (Ni_2O_3) or else acts as an absorber of oxygen in some manner unknown to me. Whatever the action may be, the oxide so treated acts as a most efficient oxygen-storing element for commercial use in a galvanic battery. The object of employing graphite, which is not affected by electrolytic oxidation, is to offer a great extent of surface against which the whole of the oxide is in contact, a large conducting surface being necessary, since the electrolytic reduction and oxidation for practical purposes only extend a small distance from the conducting surface against which the oxide is in contact. This is admirably effected by the use of graphite in its micaceous form, the proportions indicated being such as to practically insure that the electrolytic action need not penetrate a greater distance from the contact surface than the thickness of a single particle of the powdered oxide. Furthermore, there is no local action between the nickel or cobalt oxides and the graphite. The reason why nickel hydrate is preferably used instead of other compounds of nickel is that the metal itself when finally divided (as obtained by reducing a nickel compound by hydrogen or electrolysis) is not oxidizable to any considerable extent when subjected to electrolytic oxidation in an alkaline solution. The sulphide of nickel is not decomposed by electrolysis under the conditions of battery work, and the sulphide of cobalt only imperfectly. Hence the hydrates are the most available compounds for use, since they do not become inert to the same extent as hydrates of the oxides of iron after drying, they are easily prepared, and by absorbing the solution they swell within the pockets or receptacles so as to insure intimate contact and stability. During the charging of the cell the absorption of oxygen by the oxide of nickel or cobalt causes the oxide to further swell and bulge the pockets or receptacles outwardly, and on discharge a proportionate contraction takes place. In order that the walls of the pockets or receptacles may always maintain the desirable intimate contact with the active material, the pockets are, as stated, made of some highly elastic metal, such as hard rolled sheet nickel, so that at each contraction of the mass the pocket walls will by their elasticity keep in contact therewith. Having constructed the two elements of the battery as above explained, they are preferably utilized together in a solution of 25 per cent of potassic hydroxide in water and the cell is ready for use, and when charged the iron is in the metallic form and the nickel or cobalt oxide is raised to the superperoxide stage described.

"Owing to several obscure reactions which take place when the battery is discharged, and also to a change of resistance within the electrodes, the voltage is variable; but the average voltage over the whole discharge is about one volt, rising as high as 1.32 volts, and sometimes higher, when freshly charged. My improved battery can be overcharged, fully discharged, or even reversed and charged in the opposite direction without any injury. Over-gasing does not disturb the initial state of the materials in the pockets, all the ingredients are insoluble, the supporting plates are unattacked by electrolytic oxidation, and the whole operation is independent of the strength of the solution, so that the battery is of great permanence, while at the same time more energy will be stored per unit of weight than with any permanent practical combination heretofore suggested. I have constructed a battery as above described which gives an available storage capacity of one horse-power-hour for 73 pounds weight; but it may be made lighter without destroying its permanent character. The specific magnetic metals are iron, nickel and cobalt. By the expression "oxide of a specific magnetic metal other than iron" as employed in my claims, I mean oxide of nickel, oxide of cobalt or a combination of such oxides. By the use of that expression it is my purpose to embrace and include generically both of these utilized oxides."

Science Brevities

Electrolytic Manufacture of Metal Papers—One of the most recent developments in the electrolytic manufacture of metal papers is embodied in a patent recently issued to Carl Endrumeit, of Berlin, describing a continuous process for the production of metal papers or paper-backed foils, says a British contemporary. In this method an endless belt of metal moves past a rotary polishing roller, which removes stains or irregularities, then over a tank containing a dilute solution of potassium trisulphide, with which the polished face of the belt is moistened by means of a cylindrical brush. A layer of sulphide, imperceptible to the eye, but sufficient to prevent too close adherence of the metal afterward deposited, is thus made to form upon the surface, after wiping and rinsing the belt dips into the first plating vat and receives, over the sulphide, a thin coating of nickel, then into a second vat, where this film is reinforced by a heavier deposit of copper. This is followed by more brushing and rinsing, and a coating of glue is evenly applied to the layer of copper, a strip of paper is fed upon it from a roll, and belt, deposit and paper pass together through rubber compressing rolls and a drying chamber. As the deposited film adheres far more strongly to the paper backing than to the polished and treated metal belt, the finished metal-faced paper can be easily stripped and wound, while the belt passes again to the polishing roll and the electroplating vats. Using a polished cathode belt, it is claimed that a paper with a brilliant nickeled surface is obtained, and by the addition of mercaptans or other sulphur compounds to the glue the backing adheres so strongly that the product is thoroughly serviceable.

Electrolytic Ore Smelting—A report has recently been issued by the British consul at Milan on a new process of electrical smelting which has lately been experimented with in Italy. The report states that the process—known as Captain Stassano's—is claimed to be economic. The tests were begun in Rome, but lately have been carried on under Captain Stassano's personal superintendence by a company formed for the purpose at Darfo, in the province of Brescia, where a valuable water power is available. In the first place the ore is reduced to powder and then mixed with a certain proportion of powdered coal or charcoal, which is necessary for the production of carbonic acid gas. For binding purposes from 5 to 10 per cent of vegetable tar is added, and by subjecting the mixture to hydraulic pressure it is said to be effectually caked together. This is then cut into pieces of from one and one-half to two inches square, which are put into the furnace. The smelting is brought about by intense heat produced by a voltaic arc. The consul reports that at the end of last January a commission, composed of five well-known scientific men, witnessed a series of experiments with this process, and that they have reported that they consider the Stassano process to be industrially practical. The opinion is held in other quarters, however, that, as yet, no adequate proof has been furnished that the new system will not cost more, rather than less, than the one actually in use. Moreover, its application with any prospect of success appears to be dependent on the possession of a very abundant water power at very low price for the production of the electrical energy, the consumption of which is said to be enormous. All things considered, concludes the consul, it would appear to be unadvisable to adopt Captain Stassano's process until the possession of the advantages claimed for it have been much more clearly demonstrated.

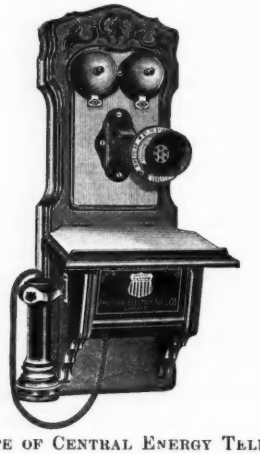
Electrolysis of Fused Salts—Ordinary experiments leave the question rather doubtful in how far, or under which circumstances, Faraday's law, which holds for solutions, can be applied to fused salts, says *Engineering*. The problem has been made the subject of a special study by Professor Richard Lorenz, of Zürich, and his pupils, and the results are of considerable interest, since pyroelectrolysis is regarded with favor by many electrochemists. Various kinds of cells are employed for experimental purposes. The V-shaped tubes of glass or porcelain are placed in baths which may be heated to high temperatures. Such baths of oil, or of melted salts, will keep a fairly constant temperature when heated by a Bunsen burner. Fletcher furnaces are more suitable, and very constant temperatures can be produced in the electric furnaces of Lorenz, Helbig and Plüss. These are carbon cylinders, packed on the outside with magnesia, and held above and below by wide copper strips, forming elastic rings; the porcelain crucible is placed within the carbon cylinder. For the highest temperatures the cylinder is pressed between carbon blocks with cooled copper electrodes. Melted zinc chlorides, and the chlorides of magnesium, lithium, aluminum, likewise to a minor degree, behave so peculiarly when electrolyzed that it looks as if there existed two modifications of this salt. The electrolytically bad—though chemically almost pure—modification develops hydrogen at the cathode, and bluish clouds make their appearance, instead of metallic zinc, while little chlorine is generated at the anode, which glows like a Wehnelt interrupter, and becomes rapidly destroyed. That the trouble is caused by the last traces of water, which are retained by the chlorine with great persistency, was long known and has been further proved by Czepinski and by H. S. Schultze. If the almost dry chloride is stirred with strong hydrochloric acid, and then evaporated to dryness, a good chloride results for electrolysis; but this chloride "ages" quickly, and reabsorbs moisture. The reason is that the reaction $ZnCl_2 + 2\ H_2O = Zn\ (OH)_2 + 2\ HCl$ proceeds more rapidly in the sense from left to right than in the opposite sense. But even in the absence of water, metallic chlorides, and particularly also iodides, undergo, in the fused condition, a kind of most undesirable dissociation. When lead chloride is kept in fusion over a layer of molten lead, the fused chloride will at first be quite clear. If the burner is turned too high brownish vapors rise from the lead, which become denser and darker as the temperature rises; on cooling the fused mass, they recondense again, leaving the chloride clear. The clouded chloride is unfit for electrolysis. There may be subchlorides in this cloud of vapor; but it is probably nothing but metallic lead which diffuses through the molten salt, and as this clouding is also called forth by the action of light, Lorenz thinks that the latent photographic image may be due to a solution of metallic silver in the silver bromide. Why does the diffused metal disturb electrolysis? The fused salt acts, according to Lorenz, as a depolarizer, both at the cathode and at the anode. At the cathode no metal is deposited before the mass has become saturated with metallic vapor, the current does not at once show its effects therefore. These vapors gradually penetrate to the anode, where chlorine, bromine or iodine are liberated, which now recombine with the metal. These latter polarizing effects are very strong, and it is owing to them that the electrolytic efficiency may be very poor. Chlorine of lead boils at 956 degrees centigrade. At that temperature electrolysis is impossible, and the mass conducts the current like a metal, and not like an electrolyte. At 920 degrees the current efficiency is 3.2 per cent; at 900 degrees, 12 per cent;

then the efficiency rises higher and higher, being 92 per cent at 540 degrees, which temperature is not much above the melting point of the chloride. These values were obtained by electrolyzing lead chloride in a V-shaped tube with bare carbon electrodes. The electrodes approach one another in the corner of the V, and from the cathode there the brown vapors spread. If these vapors are really responsible for the low efficiency, the current efficiency should improve when the vapors are prevented from diffusing over to the anode. Lorenz proved this by sheathing the cathode with a glass tube, from which only the ends project, and by further putting this tube, with its electrode inside a test tube; that is, a tube closed below, in which he made a round hole, however, about two inches from the bottom of the test tube. The anode is similarly sheathed. The arrangement would not strike one as particularly suitable for electrolysis. But the efficiency rose to 99.5 per cent at 560 degrees centigrade, and was still 96.8 per cent at 860 degrees. Faraday's law, therefore, remains valid under proper conditions, and the electrolysis of fused chlorides of the heavy metals assumes a decidedly more promising aspect.

Electric Dissipation at High Altitudes—The presence of ions in the air was suggested by the phenomena of photo-electric discharges observed by Elster and Geitel, and has been explained on the basis of the ultra-violet rays in sunlight, says the *Electrician*. Observations made on mountain tops are complicated by the increased electric density inseparable from points and eminences, and these complications can only be removed by measurements made in balloons. Herr H. Ebert undertook two balloon ascents for the purpose of determining the conductivity of air at high altitudes. One of them was undertaken in the hot summer, and the other in winter, with snow on the ground. Even in the case of a balloon ascent a new complication might conceivably be introduced by a proper charge of the balloon itself, but the author made sure against that by bringing the inflated balloon into the neighborhood of the electrometer, which showed no disturbance in consequence. The general observation made was that as the altitude increased the ratio between the rates of discharge of negative and positive electrification became more and more like unity, and at the same time both rates of discharge showed a notable increase. But the excess of positive over negative ions may often be felt at altitudes as great as 8,000 feet.

A New Central Energy Telephone.

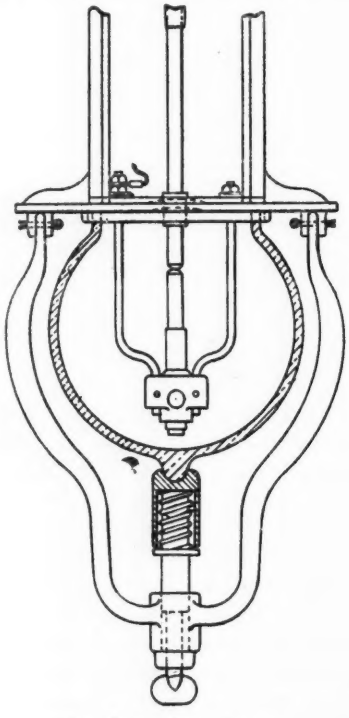
The accompanying illustration shows a compact and conveniently arranged central energy telephone set lately designed by the American Electric Telephone Company, of Chicago.



NEW TYPE OF CENTRAL ENERGY TELEPHONE.

This instrument is equipped with the gold electrode type of transmitter made by the American company and a cordless transmitter arm. It is claimed that this form of transmitter is a very powerful and satisfactory instrument, giving exceedingly clear articulation. The receiver is of a new and attractive design, its hard rubber shell containing a double-pole horseshoe magnet. The magnet coils are carried in a nickeled containing-shell insuring positive and changeless adjustment. No binding-posts are used on the receiver, connection being made by means of German silver clamps on a fibre block. The switch-hook is of the long-lever, self-contained type, and is mounted in a metal base, making it very difficult to disturb its adjustment, though connection is made through the main spring or lever joint, the switching acting merely as a switch device. The moving contacts are all platinum tipped, and the instrument is supplied with two cells of an improved form of dry battery having long life and remarkably constant electro-motive force.

Removing a single retaining-screw permits the front of the telephone to be swung on hinges and its interior exposed for inspection or repair should this be necessary. The case is of an ornamental pattern, as the illustration shows, and is made in a number of hard woods.



ARC LAMP ATTACHMENT.

A New Arc Lamp Attachment.

Mr. William H. Fitzhugh, of Bay City, Mich., has devised an improvement in electric arc lamps, the object being to provide an attachment by means of which open arc lamps may be converted into enclosed lamps. To this end a plate is secured to the bottom of the ordinary lamp frame, the adjustable carbon passing through the centre of the same. A pair of ears is located upon the under face of this plate or disk, and a yoke is pivotally hung from the ears. A circular globe having an open upper end is arranged in the yoke, with its open end bearing against the under face of the plate, which plate is provided with an annular rib and packing that form a practically air-tight joint. The globe is held in place by a stem slidably mounted in the lower end of the yoke and having a spring-pressed cup at its upper end that bears against a knob or lug arranged upon the lower end of the globe. The entire device may be readily attached to any existing lamp, and the globe removed or replaced by releasing the cup therefrom, and swinging the yoke to one side.

Under a French process, wood, treated to a bath of magnesium sulphate, is said to become fireproof. Lead electrodes are used, the one being separated from the other by a sail-cloth diaphragm. A direct current of 110 volts is passed through the wood, which extracts the sap and replaces it by non-inflammable salt. It is said that the process has been successfully applied to the manufacture of paving blocks. The rate of energy is about half an electric horse-power at 20 to 30 volts per cubic metre. The treatment of the wood lasts about 48 hours.

Current Electrical News

COMMERCIAL NEWS

DOMESTIC AND EXPORT

It is said that the Oudh & Rohilkand Railway, of India, is contemplating the purchase of about $10,000 worth of electric fans to be used in its various offices.

The Mexican National Telephone Company has been chartered at Dover, Del., with a capital of $1,000,000. The company will engage in the telephone business in Mexico, and will construct, maintain and operate telephone exchanges throughout the different states of the Republic.

The city of Simla, India, is to be lighted be electricity. The government electrical engineer of Bengal, Mr. Meares, has recently made a report suggesting that power could be secured from the falls of the river Nanti. He estimates that the total cost of the electric light scheme would be $225,000.

The several large freezing works of the Nelson Brothers, of London, located in the various parts of New Zealand, will be operated in future by electric power, which will drive the hoists and subsidiary machinery. Electric motors will be installed to take the place of long lengths of steam pipe and auxiliary steam engines.

A new concern has recently been incorporated in London for the purpose of operating electric light systems and electric railways in various parts of England and Scotland. It is known as the Urban Electric Supply Company, Ltd. The cost of the lines which the syndicate proposes to construct will be over $1,500,000.

The cities of Padang and Djokjakarta, in the Dutch East Indies, have granted concessions to H. R. der Mosch and H. Jul Toostenz for the construction and operation of electric light and power plants in those cities. Padang is the largest city on the west coast of Sumatra, and has about 30,000 people. Djokjakarta has a population of 85,000.

A bill has passed the British House of Lords and been accepted by the committee in the House of Commons, providing for the construction of an electric railway under the Solent. The tunnel will be seven and one-half miles in length and the total cost will be $3,000,000. The maximum period for the completion of the scheme has been fixed at seven years.

It is stated that the city of Paris is to have another underground railway which will cross the city from north to south, the present line, which was opened last year, crossing from east to west. The depth of the new road varies from 26 to 120 feet, and it will be four miles in length. The cost will be about $7,000,000, and the motive power will be electricity.

At a recent meeting of the Stanley Electric Manufacturing Company, at Trenton, N. J., a decision was reached to increase the capital stock from $1,250,000 to $2,000,000. Circulars have been mailed to stockholders notifying them of this increase of capital. Seven thousand five hundred new shares will be issued, and each present shareholder is entitled to six-tenths of one share of the new stock for each share now held.

In New Zealand the city council of Dunedin is considering the proposition to adopt electric traction. The representative of the Westinghouse interests in New Zealand has submitted a report recommending the overhead trolley system. It is proposed to secure the power from the falls of the Taieri River by means of turbines, transmitting it electrically to Dunedin. The estimated cost of the enterprise is $1,000,000.

According to Consul-General Guenther, of Frankfort, Germany, the demand for electric ventilators in British India is far in excess of the supply. He says that American ventilators are being introduced to a limited extent, the trouble being that the people of British India prefer ventilators with larger blades than the American generally manufactures. He believes that by meeting the peculiar demands of these people a large market could be secured for the American products.

The Russian Government has just awarded a contract to the Lidgerwood Manufacturing Company, of New York, for equipping the battle-ship Retvizan with a marine cableway for coaling at sea. This battleship is now being built at the Cramp's shipyard in Philadelphia. The cableway is to be operated by electric motors, and may be worked at sea as well as being used as a hoisting device for taking coal from a collier alongside in the harbor. The battle-ship will be able to coal from a sailing ship towed by it as well as from a steam collier towing the warship.

July 4 was celebrated at Columbus, Ga., by starting the machinery in a half million dollar electrical cotton mill. Two years ago Mr. F. B. Gordon, of that city, began the organization of a company to erect a large cotton mill, the machinery of which should be driven entirely by electricity. Boston capitalists became interested in the scheme and the result is one of the best equipped cotton factories in the country. Power and light are furnished by the Columbus Power Company, a new concern which has just established a large plant on the Chattahoochee River, near the city of Columbus.

Under a charter secured at the last session of the Canadian Legislature, the Montreal Light, Heat and Power Company has been organized. The new concern proposes to bring about the consolidation of all the tramways, lighting and power plants, and interior navigation companies of the Dominion. It nas already absorbed several concerns and has secured the right to supply electric light and power to the city of Montreal and the surrounding district. Under its present charter the company is authorized to operate within a radius of 100 miles of Montreal. Among the promoters of the enterprise is Senator Forgoe, president of the Montreal Street Railway and also president of the Richelieu & Ontario Navigation Company.

The Imperial Manufacturing Company has asked for a franchise from the St. Paul authorities to build a half million dollar plant for furnishing electric light and power for businesss concerns and residences, and also for supplying steam heat and power for business concerns. President M. D. Flower, of the company, in speaking of the company's plans, recently said: "The franchise we ask will conflict with that of the gas company without doubt, but there is no reason why there should not be competition. Many St. Paul people want electric light in their residences, and we purpose to supply them. What we plan is to erect suitable power plants in the central part of the city, and to furnish electric light and power, steam and heat for both manufacturing and domestic purposes. If we can obtain a franchise we will equip the best plant that can be built. We shall also manufacture electrical appliances."

ELECTRIC LIGHTING

The city of Albany, Ga., will build an electric light plant.

Doylestown, Ohio, is to construct an electric plant to cost about $9,000.

It is said that an electric light plant will be constructed at Haywards, Cal.

Shepherdstown, W. Va., has voted to issue bonds for the construction of an electric light plant.

The Nova Scotia Steel Company is increasing its electric light plant in the works at New Glasgow.

Business men of Clarinda, Iowa, have subscribed $15,000 for the purpose of erecting an electric light plant in that town.

In Sardis, Miss., the Sardis Electric Light and Power Plant has been organized and will construct a plant to cost $9,000.

The Citizens' Mill and Elevator, Water and Light Company, of Bardwell, Ky., is preparing to build an electric light plant there.

The Schofield Woolen Company, of Oshawa, Canada, is constructing a new light plant which will furnish lights for its factories.

The town of Ellisville, Miss., has awarded a contract to the Newman Spranley Company, Ltd., of New Orleans, La., for the construction of a $12,850 electric light plant.

The Imperial Manufacturing Company has asked for a franchise in St. Paul, Minn., and proposes to spend about $500,000 in the erection of a plant for furnishing light, heat and power.

The citizens of Manistee, Mich., at a recent election voted to issue bonds for a municipal electric lighting plant. The present commercial plant may be purchased and improved.

The Woodstock Electric Light Company, of Woodstock, Va., has awarded a contract to the General Electric Company, of Baltimore, to erect a complete electric light system in that town.

The Ginzel Construction Company has been organized at Detroit, Mich., for the purpose of building electric and gas lighting plants and doing construction work. The capital of the company is $10,000.

The Electric Light Company, of Hodgenville, Ky., will at once begin the erection of a power-house. The company has entered into an agreement with the town trustees to light the town for a period of five years.

The Westinghouse Electric and Manufacturing Company has been awarded the contract to build the electric plant for the large office building which Mr. H. C. Frick will erect in Pittsburgh. The contract is a large one and the machinery and dynamos will be specially constructed.

Capitalists from Indiana are applying to the council of Greensburg, Pa., for franchise to construct a large electric light and power plant in that city to compete with the company which recently grew out of the consolidation of the Westmoreland plant and the plants at Irwin, Jonneth and Manor. The new concern will be known as the Allegheny & Westmoreland Heat, Light and Power Company, and proposes to operate in all towns within a radius to 25 miles of Greensburg.

ELECTRICAL SECURITIES

The condition of the market for the last week has not been marked by any feature of great interest. The present seems to be a time at which the movement of the market reflects the general feeling that it is wise to call a halt, and reckon, as accurately as may be, what the future has in store. A somewhat unsatisfactory condition of things obtains in the West, where continued hot weather has worked large damage to crops, and in the East the steel strike is still unsettled. The first ground swell of the approaching political campaign is also being felt, while the financial condition and general lack of prosperity of important foreign nations all counsel considerable thought before investments are made rashly. Our export market is very strong, but some observers believe that a settlement of the difficulties in which Great Britain is now plunged and the policy of our great manufacturing rival, Germany, may unite in the future to curtail this important outlet for American goods. Meanwhile, however, there can not be said to be any lack of confidence and business is pursuing the even and uneventful course which generally marks the summer holidays.

ELECTRICAL SECURITIES FOR WEEK ENDING JULY 20.

New York:	Highest.	Lowest.	Closing.
B'klyn R. T.	79½	74¼	77¾
Con. Gas.	218½	210½	215
Gen. Elec.	260	245	255
Man. El.	12:¾	113¾	118
Met. St. Ry.	1.1½	164	168¾
Third Ave. R. R.	...	.	123
Kings County Electric..	...	...	205
N. Y. & N. J. Tel. Co...	...	...	175
Telep., Tel & Cable Co.	...	...	0¼

A slight period of speculative activity has marked Western Union this week. The story of a consolidation of this company with the American Telephone and Telegraph Company is generally disbelieved.

The Metropolitan District Electric Traction Company has been incorporated in London with a capital of $1,000,000, with Mr. C. T. Yerkes as chairman, and Mr. J. M. Brown, president of the Maryland Trust Company, secretary.

The Interstate Telephone Company of New Jersey has elected Mr. H. H. Hammill president.

In the fiscal year of 1899-1900 the Metropolitan Street Railway showed net earnings of $7,616,943. In the nine months, ended March 31, 1901, a gain of $188,000 in net earnings was shown.

For the 11 months, ended May 31, 1901, the net earnings of the Brooklyn Rapid Transit Company increased $371,038.

Boston, July 20:	Closing.
Am. Tel. and Tel.	162½
Erie Tel.	50
New Eng. Tel.	135
Mass Elec. pf.	94
Westing. Mfg. pf	79½
Edison Elec.	260

Secretary Burroughs, of the New England Electric Vehicle Transportation Company, has notified stockholders of a dividend in liquidation of $2.50 per share. Stockholders are urged to deposit their certificates as soon after Wednesday, July 24, as possible.

Philadelphia, July 20:	Closing.
Elec. Co. of A.	6⅝
Philadelphia Elec.	5¾
Union Traction.	27
United G. I. Co.	116
Elec. Sto. Bat. c.	75
Elec. Sto. Bat. pf.	75

The Consolidated Telephone Company, with a capital of $6,000,000, succeeding the Schuylkill Valley Telephone Company, is to take over the Interstate Telephone and Telegraph Company of Pennsylvania; the Standard company, of Bucks County; the Lehigh company, of Allentown; the Anthracite company, of Hazleton; the People's company, of Wilkesbarre; the Lackawanna company, of Scranton; the Carbondale company, and the Overland company, of Lehighton. This company will have close traffic relations with the Interstate company of New Jersey, and the Keystone company, of Philadelphia.

Chicago, July 20:	Closing.
Chicago Edison Light	180
Central Union Telephone	36
Chicago Telephone	275
Un. Trac	20
Un. Trac. pf.	61
Metropolitan El.	89

It is stated that the Electric Railway City & Suburban, of Cleveland (belonging to the Everett-Moore Syndicate), will be merged into a $150,000,000 corporation. Over 25 different city and interurban lines have been secured in the states of Michigan and Ohio, forming almost the belt around Lake Erie and Port Huron to Buffalo, leading southward to Cincinnati, Cleveland and Pittsburgh. One thousand two hundred and fifteen miles are in operation and 400 more are under construction, while the total earnings of the separate companies' present system at this time amount to more than $10,000,000.

PERSONAL MENTION

MR. MAXIME REBER will probably succeed Judge J. M. Thomas as manager of the United States Telephone Company, of Cleveland.

MR. NATHANIEL THAYER has been elected a director of the American Telegraph and Telephone and the American Bell Telephone companies.

MR. I. K. ROBINSON, the Westinghouse representative in Bolivia, Chili, is visiting the United States looking after some important contracts for electrical equipment which will be used in South America.

MR. ARCHER HARMAN, managing director of the Ecuadorian Association, Ltd., of 33 Wall street, New York city, sailed from New York last week for Guayaquil, where he goes to look after the establishing of an electric traction system and lighting plant.

MR. R. T. SCOTT, of Oxford, Ohio, who has for two years been superintendent of the Knoxville Electric Light and Power Company, of Knoxville, Tenn., has been appointed assistant to Manager Shepard, of the Cleveland office of the General Electric Company.

MR. F. P. VALENTINE, who recently resigned his position as superintendent of telephones of the New York, New Haven & Hartford Railroad, has been appointed superintendent of exchanges of the New England Telephone and Telegraph Company, with headquarters in Boston.

MR. W. GRATZ, who has been connected with the International Correspondence Schools, Scranton, Pa., has resigned to accept a position with Mr. Elmer G. Willyoung, New York, maker of electrical measuring instruments. Mr. I. McC. Bean, formerly of the Dickson Manufacturing Company, has succeeded Mr. Gratz as editor of *Science and Industry*.

OBITUARY NOTICES

JUDGE D. A. RUSSELL, of Pomeroy, Ohio, treasurer of the Pomeroy & Middleport Electric Railway Company, died suddenly in Cincinnati on July 12. In addition to his railroad interests, Judge Russell was connected with a number of enterprises in his section of the state.

MR. THOMAS M. ROGERS, president of the Worcester Electric Light Company, died at his home in Worcester, Mass., on Tuesday, July 9. Mr. Rogers was a director in several banks, and was one of the largest real estate owners in his city. He was eighty-three years of age.

LEGAL NOTES

THE MONTREAL COURT OF APPEALS has confirmed the verdict of a lower court awarding $5,000 damages against a light company to the widow and children of a hotel keeper who was killed by taking hold of an electric lamp. The court held that the company was bound to provide a safe current for the lamps installed in the premises. It was supposed that during a rain-storm an unusual current escaped to a frayed wire leading to the house from a point just below the transformer, or that at the time the deceased took hold of the lamp the wire got some or all of the current from a powerful feed wire, which passed near. The burden of proof was upon the company to show that the leak of current did not come from its wires.

THE MARYLAND SUPREME COURT has recently held, where a turnpike company had granted an electric railway company the right to operate its lines over the turnpike, "for the transportation of passengers and such bundles and parcels as are now customary to be carried on the city and suburban electric railway lines," that as it was intended that the turnpike company should continue the operation of its road for the transportation of freight, and as it was not the general custom of electric railway lines to run freight cars, and as there was no evidence at the time of making the contract that the turnpike company had knowledge of the running of such cars by the electric railway, the railway company was therefore not entitled to run a car designed for general freight.

IN THE CASE OF THE DETROIT, FORT WAYNE & BELLE ISLE RAILWAY COMPANY *vs.* the Commissioner of Railroads, the Supreme Court of Michigan has sustained the law which authorized the railroad commission of the state to prescribe safeguards at the crossings of electric and steam railroads and to apportion the expense of providing them. An order was made by the commissioner for safety gates at the Clark avenue crossing of the tracks of the Union Terminal Association in the city of Detroit and for derailers in the tracks of the street railroad company, such gates and derailers to be operated by a watchman from a tower, and the expense of construction, maintenance and operation to be equally divided between the two companies. It appears that the Union (steam) line was the last one built, and on account of this the electric line claimed that it could not be required to pay any part of the expense, but the Court holds that the statute applies to the case.

THE SEABOARD TELEGRAPH AND TELEPHONE COMPANY, of New York, has secured a writ of mandamus, from Judge Garrettson, of the Supreme Court, directing Commissioner Kearney, of the Department of Public Buildings, Lighting and Supplies, to permit it to repair its line in Queens Borough. This permit was refused two years ago by Deputy Commissioner Fowler, of Queens, because the Seaboard had abandoned its lines, and its poles and wires were down, and in the meantime the New York & New Jersey Telephone Company had constructed a parallel line. The charter of Greater New York forbids the erection of two lines of poles bearing conductors of a like class in any street or avenue, and the Deputy Commissioner held that the reconstruction of the Seaboard's lines would be a violation of this provision of the charter. Judge Garrettson ruled that the Seaboard was owner of a franchise to build and operate its lines; that there was nothing to show it had lost this right; that the wires and poles were a menace, and therefore the line should be reconstructed in order to remove liability of accident or injury to the public; that the Seaboard was not answerable for there being parallel lines, inasmuch as its lines were first constructed. The mandamus was therefore granted.

ELECTRIC RAILWAYS

Trolley lines will soon connect the Kentucky towns of Lexington, Georgetown and Paris.

The electric railway system of Victoria, British Columbia, is being extended at a cost of $100,000.

The Birmingham, Ala., Electric Railway Company proposes to construct a line from Pratt City to Wilam, Ala.

The Montreal Street Railway Company, Montreal, Canada, has purchased the Park & Island Railway and suburban lines, at a cost of $1,100,000.

Work has been commenced on the electric street railway line between Alliance, Ohio, and Sebring. The length of the line will be about four miles.

The city council of Terrell, Tex., has been asked by R. D. Wortham, representing a combination of St. Louis capitalists, for a street railway franchise.

The Quakertown Traction Company, of Quakertown, Pa., is contemplating the construction of a trolley line from Doylestown to Perkasie and Quakertown, Pa.

An electric railway will be built from Green Castle to Pen-Mar, Pa., a distance of 14 miles, by the Chambersburg, Green Castle & Waynesboro Railway Company.

It is stated that the Wheeling Traction Company of West Virginia will extend its lines from Martin's Ferry to Brilliant, Mingo Junction, and Steubenville, Ohio, at an early date.

About a mile of the electric road from Little Falls to Herkimer, N. Y., has been graded. Rails and ties for the entire distance have been ordered for immediate delivery.

The Covington & Erlinger Street Railway Company, of Cincinnati, Ohio, has commenced the work of constructing an electric railway between Erlinger and Cincinnati.

The Indianapolis, Danville & Western Traction Company proposes to build an interurban electric line from Indianapolis to Danville. Cincinnati capital is promoting the enterprise.

The work of surveying the new electric trolley road between Seymour and Ansonia, Ct., has been commenced. The construction of the line will begin as soon as the engineers have finisned.

The syndicate owning the Madison, Wis., street railway and the Kilbourne City power plant has decided to build an interurban line between Madison and Janesville, Wis., by way of Edgerton.

The Schenectady Electric Company, of Schenectady, N. Y., has begun an extension of its line to Scotia. The road will be rapidly pushed forward, and will be finished in the course of a few weeks.

At Coldwater, Mich., work has been commenced on the Battle Creek, Coldwater, Electric Railroad. Poles are being distributed along the route and work will be pushed as rapidly as possible.

At a recent meeting of the village board of Pittsford, N. Y., the application of the Monroe County Belt Line Electric Railway Company for a franchise to run the road through the village was granted.

The State Board of Railway Commissioners of New York has granted to the Oneonto, Cooperstown & Richfield Springs Railroad Company a permit to increase its capital stock from $750,000 to $1,000,000.

New York capitalists have secured right of way for an interurban line from Fond-du-Lac to Oshkosh, Wis., a distance of about 20 miles. Work will begin on the line this fall and will be rapidly pushed to completion.

The Amsterdam Street Railway Company has been granted a franchise by the town of Amsterdam, N. Y., to extend its lines through the town along the turnpike to the Schenectady County line just west of Hoffmann's.

A Chicago syndicate has filed a petition with the city council of Valparaiso, Ind., asking for a franchise for an interurban car line connecting that city with Chicago, Michigan City, Laporte, Hammond and South Bend.

The Sauk Power and Traction Company has petitioned the council of Baraboo, Wis., for a permit to construct a line of electric railway through that place. The line will connect Devil's Lake and the dells of the Wisconsin River.

Arrangements have been perfected for the extension of the trolley service from Paterson, N. J., to North Paterson, and it is said that the plan contemplates the extension of the system to Ridgewood, in Bergen County, at an early date.

Parker & Company, financiers of Indianapolis, Ind., have secured the franchise which was granted to Mr. Mitchenor, of Indianapolis, last fall, to build a road from Valparaiso to Michigan Beach. The line is also expected to have connections with Chicago and cities in northern Indiana.

At the first annual meeting of the directors of the Des Moines, Nevada & Eldora Railway Company, held at Des Moines, Iowa, July 3, the following officers were elected: H. H. Pope, Des Moines, president; W. P. Swansee, of Nevada, vice-president; D. F. Kaufman, treasurer; G. B. Hippe, secretary.

At Stevens Point, Wis., the common council has granted the Wisconsin Valley Lighting and Power Company a franchise to construct and operate an electric railway through the city. The company will build a line from Stevens Point to Grand Rapids, and the work will commence in September.

The Northern Ohio Traction Company has secured from the city council of Wadsworth, Ohio, a franchise for its lines through that city. Wadsworth will be on the line of the Canton, Akron & Massillon Railway Company, in which the Ohio Traction Company is interested. Rights of way have been secured for almost all of the entire route.

The People's Railway Company, Wilmington, Del., has decided to double the capacity of its power station and the necessary machinery will be ordered at once. The additional machinery will necessitate the enlarging of the power-house and will consist of three engines, three dynamos, and some additional boilers. The new machinery will give the company a capacity for handling 200 cars.

The board of supervisors of San Jose, Cal., has granted a petition to George T. Dunlap for three more electric franchises. The proposed lines will run from San Jose to Santa Clara and Alviso, from Santa Clara to the county line on the north in the direction of San Francisco, and from San Jose to Los Gatos by way of Campbells. Under the terms of the franchise, work must begin on these roads within six months, and must be completed within two years, or the franchise will be forfeited. The length of the entire system will be 90 miles.

NEW INCORPORATIONS

ST. JOSEPH, MO.—Column Mercantile Company. $25,000. Incorporators: B. J., John and Martin Dunn.

JOLIET, ILL.—Chicago & Joliet Electric Railway Company has increased its capital stock from $605,000 to $2,300,000.

McLEAN, ILL.—Palmer-Darnell Electric Company. $10,000. Incorporators: H. M. Palmer, W. C. Darnell and F. W. Aldrich.

EAST ST. LOUIS, MO.—Union Traction Company. $50,000. Incorporators: William K. Murphy, W. S. Wilson and W. L. McCandles.

MECHANICSVILLE, IOWA—Mechanicsville Telephone Company. $3,500. George W. Fall, president; Charles E. Gould, secretary.

McNABB, ILL.—McNabb Mutual Telephone Company. $2,500. Incorporators: John N. Wilson, W. L. Mills and Vivan Haws.

CHARLESTON, ILL.—Consumers' Gas, Fuel and Electric Company. $5,000. Incorporators: Joseph Cluke, Charles V. Newman and others.

RALEIGH, N. C.—The Rockingham Company. To develop water power and operate mills and electrical plants at Spray, N. C. Capital, $100,000.

JEFFERSON CITY, MO.—Charles S. Lyttle Telephone Company. $5,000. Incorporators: Charles S. Lyttle, W. E. Johnson, William Bevens and others.

TRENTON, N. J.—Toulumne Power and Development Company. To manufacture electricity. $250,000. Incorporators: Edward B. Hawkins, Alfred G. Brown, Herbert S. Murphy.

OKLAHOMA CITY, OKLA.—Long-distance Telephone Company. $5,000. Directors: George Todd, Oklahoma City; E. D. Nimms, Roff, Indian Territory, and F. Noble, Shawnee.

COLUMBUS, OHIO—Columbus, Newark & Eastern Traction Company. $10,000. Incorporators: R. H. York, H. J. Uhl, A. C. Collins, N. T. Horr, and A. R. Horr, all of Cleveland.

TRENTON, N. J.—United States Power Company. To build steam engines and other machinery. $250,000. Incorporators: J. Wesley Allison, Kenneth McLaren and William M. Malloy.

LOS ANGELES, CAL.—The San Bernardino County Traction Company, which is backed by the citizens of Redlands, Cal. To build a trolley line connecting Redlands, San Bernardino and Colton.

MADISON, WIS.—Luxemberg Telephone Company. To build telephone lines in Kewaunee and Brown counties. $1,000. Incorporators: Dr. Felix Moraux, F. H. Patterson, Peter Boucher and A. J. Peterson.

COLUMBUS, OHIO—The Marysville, Delaware, Sunbury & Mt. Vernon Railway Company. To operate an electric road between Marysville and Mt. Vernon, through the counties of Union, Delaware and Knox. $10,000. Incorporators: B. L. McElroy, F. D. Simons, T. A. Simons, C. E. Miles and J. W. Holcomb.

JAMESTOWN, N. Y.—Home Telephone Company. To operate a telephone system in Cattaraugus and Chautauqua counties, N. Y., and Warren and Erie counties, Pa. $200,000. Directors: Julius V. Aulnet, Jr., E. E. Nash, C. B. Selby, G. B. Devoe, Warren, Ohio; P. G. Hoyt, M. N. Skiff and E. P. Putnam, Jamestown.

TELEPHONE AND TELEGRAPH

Norwood, Pa., has granted the United and Keystone State Telephone companies permission to erect lines through its streets.

The Seattle Automatic Telephone Company has notified the city that it has 300 telephones in operation—the number required by its franchise.

The Enterprise Telephone Company, Montgomery County, Md., is contemplating the establishing, in Rockville and Laurel, of telephone exchanges equipped with long-distance instruments and metallic circuits.

At a recent meeting of the Union Telephone Company, at Alma, Mich., a dividend of two per cent was declared, and it was voted to increase the capital stock of the company to $200,000, for the purpose of extending its lines in the territory north of Lansing.

The Stoddard Telephone Construction Company has been granted a franchise by the common council of Munroe, Mich., for a telephone system in that city. The company is composed of local capitalists and will connect with the lines of the United States Telephone Company.

Mr. Charles E. Hull, of Salem, Mo., has secured from the board of supervisors of Clinton County a franchise to construct a telephone line along the highways of that county. The system will be operated in connection with the system of Marion County, which is owned by Mr. Hull.

The work of building the telephone line of the Stark County Telephone Company from Canton to Alliance, Ohio, was completed last week, and the new line was opened for business. Two pairs of copper wires have been strung and more will be added as the business demands.

Fifteen northern Indiana telephone companies have been consolidated under the name of the American Home Telephone Company. The new combination will have working arrangements with the People's Telephone Company, of Detroit, and other Michigan companies connected with the Michigan Association of Independent Companies.

The Interstate Telephone Company of New Jersey has purchased a controlling interest in the Paterson, Passaic & Suburban Telephone Company, of Paterson, N. J. The Interstate company, which has been trying to reach Jersey City, now has franchise rights as far as Rutherford. At a meeting of the company's stockholders at Trenton, N. J., on July 17, a proposition was ratified to increase the capital stock to $5,000,000.

The Citizens' Telephone Company, of Houston, Tex., is making some extensive improvements in its lines. Three miles of underground cables will be laid on streets which the city is to pave this year. The company has the principal interest in the toll line which is now being constructed between Houston and Beaumont, and it is probable that it will construct a similar line between Houston and Galveston before the close of the year.

It is reported that a plan is on foot for the consolidation of eight independent telephone companies of eastern Pennsylvania. The company which will absorb these concerns is the Consolidated Telephone Company, with a capital of $6,000,000. The new system is to include the Interstate Telephone and Telegraph Company of Pennsylvania; the Standard Telephone Company, of Bucks County; the Lehigh, of Allentown; the Anthracite, of Hazleton; the People's, of Wilkesbarre; the Lackawanna, of Scranton; the Carbondale, of Carbondale, and the Overland, of Lenighton.

AUTOMOBILE NOTES

The Electric Vehicle Company, of New York, is shipping a lot of automobiles to the City and Suburban Electric Carriage Company, of London.

At a recent meeting of Chicago automobilists Mr. Hibbard gave an interesting exhibition of the ease with which his machine, being driven at a rapid rate, might be stopped. It is said that his motor, going at 35 miles an hour, was stopped inside of 100 feet.

United States Consul-General Guenther, of Frankfort, Germany, reports that the Eagle Velocipede Works of that city have built an automobile for fire departments. The machine carries four men, has a speed of 11 miles an hour, and is expected to be used in rendering the first aid in case of fires.

The good roads of Sweden are inviting the introduction of the automobile. A French company proposes to establish a line of motors in Stockholm for public hire, and a syndicate has also been formed to run passenger and baggage cars in the northern part of Sweden to handle the tourist traffic.

An automobile auction which was recently attempted in New York city proved a failure, and the experiment will probably not be tried again for some time. The failure of the scheme was no doubt very gratifying to dealers who remember what havoc these auction sales played with the bicycle business a few years ago.

An automobile stage line will soon be in operation between Sheridan and Buffalo, Wyo., a distance of 50 miles. The stage will have accommodations for nine people and their baggage and is expected to make the round trip each day. The weight of the vehicle is 1,500 pounds and it will be propelled by a 10-horse-power gasoline motor.

Increased interest in automobiles is making itself felt in the Patent Office at Washington, whither inventors are hurrying with all sorts of devices for improving motors and parts of carriages. Five special examiners are kept busy and four separate divisions have been organized to which automobile patent papers are referred. These four divisions handle electric motors, steam motors, gas motors and compressed air motors. It is said that the only time in the history of the Patent Office when any department was more severely taxed than the automobile department is at present, was when the bicycle craze was at its height a few years ago and 10 men were kept busy handling the patent claims for bicycle parts.

INDUSTRIAL ITEMS

GEORGE WEBSTER, Christiana, Pa., is placing on the market the Diamond cord adjuster for the arranging and placing of incandescent lamps at any height.

THE STANLEY ELECTRIC MANUFACTURING COMPANY, Pittsfield, Mass., last week voluntarily advanced the wages of its operatives in all departments five per cent, and granted a half holiday on Saturday.

THE UNION MICA COMPANY, 56 Pine street, New York announces that it is now prepared to fill orders for mica at particularly low prices. The company also announces that it is its own miners of mica.

THE ELECTRIC APPLIANCE COMPANY, of Chicago, is manufacturing the Eaco visual signal telephone switchboard. The company claims that this device gives the same service as an electric light board and does away with its disadvantages.

THE O. C. WHITE COMPANY, Worcester, Mass., has an exhibit at the Pan-American Exposition of its standard adjustable electrical fixtures, including some new types of this equipment. Its exhibition is in the northeast corner of the Electricity Building.

THE CENTRAL ELECTRIC COMPANY, of Chicago, Ill., sales agent for the well-known Okonite wire, reports a brisk demand and large sales of same. The company carries a large stock of this brand, as well as cheaper grades of rubber-covered wire, and also bare copper, double galvanized, telephone magnet and annunciator wires.

THE GENERAL ELECTRIC COMPANY has prepared a catalogue of its lightning arresters for continuous and alternating-current circuits, which contains descriptions and diagrams of these devices, with a beautifully illustrated and well-written article on "Thunder-storms," by Mr. A. F. Sims, the local forecast official at Albany, N. Y.

D. M. STEWARD, Chattanooga, Tenn., advises that owing to difficulty with the stockholders the D. M. Steward Manufacturing Company, manufacturer of the lava electric insulators, will cease to exist after July, 1901, and that he will continue as sole manufacturer of this class of product under his own name with offices at 107 Chambers street, New York.

THE WESTERN ELECTRICAL SUPPLY COMPANY, of St. Louis, who are exclusive territorial agents for the Western Telephone Construction Company, states that its telephone department is crowded with orders, and that it has been meeting with unusual success with the new central battery system. This company has been especially successful with this system in small exchanges. It states that wherever it has been installed it has given entire satisfaction in every way. It has recently gotten out a set of bulletins covering a number of entirely new telephone devices, which will be mailed upon application.

SIPE & SIGLER, Cleveland, Ohio, manufacturers of the Willard battery at the present time, have under way the construction of 12 large plants of Willard batteries, including street railway batteries, central station batteries, large isolated lighting plants and batteries in government coast defense work. The latest contract is for a storage battery for the Cleveland Electric Railway Company, which will probably be the largest battery in street railroad service in the world. This battery will consist of 282 cells of 4,000 ampere-hours capacity, and will weigh nearly 500 tons when completed. The Cleveland Electric Railway Company, for which this battery is to be installed, owns and controls more than 200 miles of street railroad. It recently installed in one of its branches two Willard batteries, and to the satisfactory operation of the same is largely due the present large installation.

THE LEHIGH VALLEY RAILROAD is offering special attractions to tourists visiting the Pan-American Exposition. This road maintains the famous "Black Diamond Express," which is one of the most unique and elaborately equipped trains in the world. A gentleman making this trip, even though recently he had been through the grand scenery of the Rocky Mountains and Yellowstone Park, was impressed with new enthusiasm for the beauties of American scenery as he saw it along this beautiful railroad. The rich and varied Wyoming Valley, often characterized as the "Switzerland of America," is traversed, and around Mauch Chunk, at the foot of the Blue Mountains, the trains of this railroad carry one to new and effective views. The route is then through one of the most artistic parts of the Empire State, near lakes Seneca and Cayuga, and thence to Geneva, Rochester and Buffalo. An attractive feature of the through trains on this road is that the dining service is *a la carte*, so that travelers may enjoy meals at the hour they please. At this season the company allows holders of season tickets and all passes a stop-off of 10 days at Buffalo for viewing the Pan-American Exposition.

List of Electrical Patents Issued Last Week

[Specially reported for this journal by E. S. Duvall. solicitor of patents, Loan and Trust Building, Washington, D. C. Copies of any patent may be secured for 10 cents each.]

ISSUED JULY 16, 1901.

678,369 Calling appliance for telephone switchboards; F. R. McBerty, Downers Grove, Ill.

678,383 Electric arc lamp; W. H. Fitzhugh, Bay City, Mich.

678,394-395 Telegraphic instrument; J. J. Ghegan, Newark, N. J.—An armature, a pivoted armature-lever, an electromagnet, a movable support for the armature-lever, a fixed support for the armature-lever support, a connection between said supports, and an eccentric for actuating said connection to vary the position of the armature.

678,410 Electrically heated tool; H. W. Leonard, East Orange, N. J.

678,426 Electric clock; E. Rosi; Arquata-Scrivia, Italy.

678,436 Storage battery; D. P. Perry, Chicago, Ill.—A battery having an element consisting of a series of disk or plate-like members arranged side by side, a conductor extending transversely through said members and secured thereto, active material between each pair of members, and absorbent material between the members of each pair.

678,443 Storage battery; W. J. Still, Toronto, Canada.

678,446 Enclosed electric arc lamp; E. P. Warner, Chicago, Ill.

678,475 Electric signaling system; H. G. Carleton, New York, N. Y.

678,482-483 Electric arc lamp; J. H. Hallberg, New York, N. Y.—A supporting tube, a bracket secured to the tube, a magnet carried by the bracket, a movable sleeve located within the magnet and connected at its upper end to a dash-pot, a dash-pot piston pivotally mounted on the top of the magnet, a second sleeve or armature surrounding the supporting tube, and a clutch mechanism connected to the second sleeve.

678,492 Electric switch; C. A. Hussey, New York, N. Y.

678,505 Telegraphic transmitting, receiving and translating arrangement; Alex. Muirhead, Shortlands, England—An automatic telegraph-transmitter, comprising a main driving-shaft, a friction-drive mounted thereon, an electromagnetically actuated pawl governing the movements of the main driving-shaft, contact-levers, electromagnetically actuated pawls governing the movements of the contact-levers, and means serving at will to retain all the said pawls out of engagement.

(Continued on page 32.)

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PATENTS.

(Continued from page 31.)

678,508 Underground conduit; J. T. McRoy, Chicago, Ill.

678,509 Long-distance relay magnetic telephone; Jacques Nessel, Brest, France.

678,512 Storage battery; D. P. Perry, Chicago, Ill.

678,517 Electric arc lamp; W. F. Ritter, Cincinnati, Ohio.

679,518 Variable-pressure, electric-current transformer; C. J. Ritzer, Schenectady, N. Y.

678,522 Electrically heated cooking utensil; M. Seips, Meriden, Ct.

678,526 Apparatus for the recovery of gold from cyanide solutions; C. P. Stewart, Oakland, Cal.

678,544 Electric light wire molding; F. H. Corduan, Brooklyn, N. Y.

678,559 Current-collector or trolley for electric railways; W. Grunow, Bridgeport, Ct.

678,560 Electric arc lamp; J. H. Hallberg, New York, N. Y.

678,566 Phonic apparatus; D. Higham, Winthrop Highlands, Mass.

678,576 Electric arc lamp; G. M. Lane, Newark, N. Y.

678,607 Electric arc lamp; J. J. Wood, Fort Wayne, Ind.

678,608 Magnetic puzzle; J. L. Woolf, New York, N. Y.—Comprises a closed box of non-magnetic material, transparent so as to optically expose the interior, and provided with an aperture, and a needle-shaped armature resting loosely within the box, adapted to be withdrawn therefrom through said aperture by means of a magnet.

678,632 Toll apparatus for telephones; E. P. Baird, Evanston, Ill.

678,633 Telephone toll apparatus; E. P. Baird, Evanston, Ill.

678,646 Rotor for alternating-current generators; E Danielson Stockholm, Sweden—A rotor for dynamo-electric machines in disk form and of increasing thickness from periphery toward the centre.

678,664 Electric motor controller; D J. Hauss, Cincinnati, Ohio—A series of stationary contacts, connections leading therefrom to the motor, the field coils and the source of electricity, a blow-out coil, a circuit-breaker separate from the controller, a series of sliding contacts adapted to cut the motor into and out of circuit, and means for cutting the blow-out coil into the circuit before breaking the motor-circuit at the sliding contacts.

678,677 Electric sign; T. E. Murray, New York, N. Y.

678,706 Electrical measuring instrument; E. Weston, Newark, N. J.—A frame or spool and a coil wound thereon, said parts being supported by a detachable or removable core.

678,707 Art of manufacturing movable coils for use in connection with electrical measuring instruments; E. Weston, Newark, N. J.

678,708 Apparatus for construction of movable coils of electrical measuring instruments; E. Weston, Newark, N. J.

678,746 Method of telegraphing, indicating time, or actuating mechanism electrically; C. R. Loubery, Paris, France.

678,803 Device for the production of continuous current in regular pulsations; E. Van Haanen, Vienna, Austria—A device for producing pulsations of a continuous current, of which the maxima of tension produced in quick succession are higher than the tension of the current generated originally, said device consisting of a condenser being in a shunt of the line circuit, the latter being provided with an adjustable resistance, and the shunt-circuit being provided with a variable spark-producer.

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